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PUBLIC DOCUMENT..... .....No. 41.

# REPORT

OF THE

## JOINT COMMITTEE OF 1860

UPON

# THE PROPOSED CANAL

TO UNITE

## BARNSTABLE AND BUZZARD'S BAYS,

Under the Resolve of April 4, 1860, and subsequent Resolves and Votes of the Legislature.

BOSTON:
WRIGHT & POTTER, STATE PRINTERS,
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## ERRATA.

Page 27, line 35, before "mouth" insert "the."
Page 32, line 2, for "17" read "11."
Page 33, line 15, for "on the western route it is" read "the western breakwater is."
Page 33, line 16, for "on the outer route it is" read "the outer route is."
Page 41, line 12, for "offered" read "offer."

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# PLANS AND SURVEYS REFERRED TO IN THE REPORT.

1. Plan and Survey made under the direction of the Committee, by J. G. Chase, Engineer.[1]

2. Plan and Survey made by W. H. Dennis by the U. S. Coast Survey Corps.[2]

3. Diagrams accompanying Mr. Mitchell's Report, from 1 to 6, inclusive.[1]

4. Soundings in Barnstable Bay. A re-survey, under the direction of John Wilkinson, U. S. N. 1860. Soundings in Buzzard's Bay. A tracing from a Survey made under the direction of Lieutenant Commanding G. S. Blake, U. S. N., Assistant U. S. Coast Survey. 1845.[1]

5. Plan and Report of Thomas Machin. 1776. In the Secretary's office.

6. Plan of John Hills. 1791. In the Secretary's office.

7. Survey of Mr. Bacheller. Not found.

8. Plan and Survey of L. Baldwin. 1818. A tracing used. The original is in the Bureau of Topographical Engineers, Washington.[1]

9. Plan and Survey of Major Perault. 1825. A tracing used.[1]

[1] These papers are in the Library, and have written thereon the reporter's name, and "November 5, 1862." No. 3 of Mr. Mitchell's diagrams is missing.

[2] Was not returned to the Committee of 1860.

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# Commonwealth of Massachusetts.

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The Joint Committee of the Legislature, appointed under a Resolution passed April 4, 1860, to sit during the recess, and examine into and consider the subject of connecting Buzzard's Bay with Barnstable Bay by a ship channel or canal, for the purposes of navigation, with power and authority to send for persons and papers, employ engineers, make surveys and soundings, collect statistics, examine localities, and to do all other things necessary to enable them to determine upon the practicability of constructing such channel or canal, and upon the best route therefor, as also its cost and form of construction, together with its value to commerce, and the means by which it should be constructed, with directions to report the same, with plans for its construction on the best route, and estimates of its cost, together with all other matters necessary to form a judgment on the same, submit the following

## REPORT:

That, on entering upon the duties assigned them under the above recited Resolution, the Committee soon discovered that the subject they were ordered to investigate had for a long time agitated the public mind, and that the measure embraced in the Resolution had received a large amount of individual attention, and had repeatedly, during the last one hundred and fifty years, been presented to the legislature as an improvement demanded on principles of general economy and of humanity.

In view of the importance of the subject, and of the unceasing efforts for its accomplishment on the part of its friends and

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supporters, the Committee concluded, while the explorations and surveys upon the premises were being prosecuted, to collect such historical facts and incidents touching the proposed canal as their means and opportunities would allow, and to embody them with the commercial statistics involved in the inquiry, together with a careful exploration and survey of the locality, and best plan of the proposed canal and its incidents, accompanied with an estimate of its cost, which they might procure; and to place the whole in such form as would present to the public all the facts essential to the formation of an opinion upon the importance, necessity, and practicability of the undertaking.

In searching for the origin of the belief entertained in the necessity and practicability of connecting the two bays by a navigable canal, they found, by a recurrence to the history of Plymouth Colony, that its settlers experienced the dangers of a navigation around Cape Cod, and early availed themselves of the advantages of the isthmus and its rivers in carrying on the commerce which their situation and condition imposed upon them. In 1622, "the crop proving scanty, partly through weakness for want of food, the settlers embraced the opportunity of buying from a Virginia ship, sent to survey the shoals about Cape Cod, knives and beads * * * paying in beaver; and being thus fitted to trade for both corn and beaver, they assayed to go around Cape Cod, to the southward, but were often baffled in their attempt, until, in November, the governor being one of the party, they succeeded in passing to the south of the Cape. (This was the first adventure around the Cape). At Nauset they bought eight or ten hogsheads of corn and beans. They secured an additional supply at Mattachiest." Their shallop was cast away, and leaving their purchases to the care of the Indians, they returned to Plymouth on foot.[1] Soon after January, 1623, "needing more corn they, with Hobamok and others, went to Manomet, twenty miles south of Plymouth, a town[2] standing on a fresh river running into a bay towards Narraganset. 'Twill bear a boat eight or ten tons to this place. Hither the Dutch or French and both used to come; it is

[1] Freeman's History of Cape Cod, Vol. i. pp. 104-106, cites Prince and Winthrop. 14 Mass. Hist. Coll. History of Wareham.

[2] Indian settlement at Herring Pond and Manomet.

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hence to the Bay of Cape Cod about eight miles, out of which bay the sea flows into a creek (Scusset River) almost directly towards the town. The heads of this creek and river are not far distant."[1]

"March 25, 1623, Captain Standish went again to Manomet for the corn the governor had bought, entering Scusset harbor with his shallop."

In 1627, the Plymouth colonists had already established a trading house at Manomet, (Sandwich,) and now built a pinnace there for their better accommodation, to avoid the dangerous navigation around the Cape. By transporting their goods up the creek from Scusset harbor, to within four or five miles of the trading house, and then taking them a short distance by land, until they reached the boatable waters of the river on the opposite side, they were enabled to make their voyage southward in less time, and without hazard. They not only erected a house here, and kept up a trading establishment, but planted, and raised swine; and the establishment became one of much importance, not only as affording facilities for trading on the south side of the Cape, but for commercial intercourse with the Narraganset country and the entire coast of Long Island Sound.[2]

The first communication between the Plymouth Colony and the Dutch, at Fort Amsterdam, was through this channel. De Razier, Secretary of the Dutch Government, arrived at the trading house at Manomet in September, 1627, (some writers say 1628,) in a vessel laden with sugar, linen, stuffs, &c. The Dutch continued this trade, which was extremely advantageous to the people of Plymouth, until they were driven off by the Virginians. In this trading intercourse the Dutch communicated to the Plymouth colonists information which lead first to trading expeditions to, and afterwards to the permanent settlements upon, Connecticut River.[3]

This use of the isthmus, in connection with the reasons given

[1] Freeman's History of Cape Cod, Vol. i. pp. 104–106, cites Prince and Winthrop. 14 Mass. Hist. Coll. History of Wareham.

[2] The location of this trading establishment was not far from what is now called Monument Bridge, the Indian Manomet being corrupted to Monument.

[3] History of Cape Cod, Vol. i. pp. 113–115. Memoir of Plymouth Colony, pp. 146–149, 210. Bradford. 14 Mass. Hist. Coll. History of Wareham.



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to show its necessity, would naturally suggest the idea of making a channel between the bays whenever the commerce seeking that passage and the ability of the colonists would justify the measure. Such an improvement was doubtless early spoken of. The first mention of such a project, however, which has come to the notice of the Committee, is found in the diary of Samuel Sewall, in the following words: —

"26 Octo'r, 1676." "Mr. Smith [of Sandwich] rode with me and showed me the place which some had thought to cut, for to make a passage from the south sea to the north. He said it was about a mile and a half between the utmost flowing of the two seas in Herring River and Scusset—the land very low and level. Herring River exceeding pleasant, by reason that it runs pretty broad, shallow, of an equal depth, and upon white sand. He shewed me also three hills, on which the four towns kept wardens, before which was such an isthmus of about three miles, and barren plain, that scarce any thing might pass unseen. Moniment harbor said to be very good."

The Charter of William and Mary united the two colonies in 1691, and twenty-one years after the entry in Mr. Sewall's diary, the subject of uniting the two bays was considered by the General Court of Massachusetts. The following is the record:—

"Octo'r 30, 1697. In the House of Representatives.

"*Whereas*, it is thought by many to be very necessary for the preservation of men and estates, and very profitable and useful to the public, if a passage be cut through the land at Sandwich from Barnstable Bay, so called, into Monament Bay, for vessels to pass to and from the western part of this country,

"*Ordered*, That Mr. John Otis, of Barnstable, Capt. William Bassett and Mr. Thomas Smith, of Sandwich, be and hereby are appointed to view the place, and make report to this Court, at their next sessions, what they judge will be the General Conveniences and Inconveniences that may accrue thereby, and what the charge of the same may be, and probability of effecting thereof."

The House passed the order, which was concurred in by the Council. But the records do not show any report of the committee.

In Prince's Annals, page 106, under date of 1736, the isthmus is described and spoken of as "the place through which there has been a canal talked of this forty years, which would be a

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vast advantage to all the country by saving the long and dangerous passage around the Cape, and through the shoals adjoining."

The next application to the General Court was in 1776, when the following preamble and resolution was adopted [May 1, 1776] :—

"In Council. Whereas, it is represented to this Court that a navigable canal may without much difficulty be cut through the isthmus which separates Buzzard's Bay and Barnstable Bay, whereby the Hazardous Navigation round Cape Cod, both on account of the shoals and enemy, may be prevented, and a safe communication between this colony and the southern colonies be so far secured,—

"*Resolved*, That James Bowdoin and William Sever, Esqrs., with such as the Hon. House shall join, or the major part of them, be a committee to repair to the town of Sandwich, and view the premises, and report whether the cutting a canal as aforesaid be practicable or not. And they are hereby authorized to employ any necessary surveyors and assistants for that purpose."

The House concurred in the adoption of the resolution, and joined Col. Freeman, Brigadier Godfrey, and Mr. Cushing.

This committee employed Thomas Machin, then in the service of the United States, as an engineer, who examined and surveyed the route, made a plan of the same, with estimates of the expense of the proposed work. The survey was incomplete in some particulars, for want of time on the part of the engineer, Mr. Machin being ordered by General Washington to New York in June, 1776.[1]

This survey makes the highest land on the route thirty-three feet and eight inches above low-water mark in Buzzard's Bay, and thirty-three feet and four inches above low-water in Barnstable Bay, in common tides, according to observations; and the rise of common tides in Buzzard's Bay to be four feet, and in Barnstable Bay twelve feet; while spring tides rose to six feet in the former and sixteen in the latter. Upon this view of the tides, the engineer proposed a canal, to be filled from the water in Barnstable Bay, to be fourteen feet deep, having two double locks at each end, with two bridges, and requiring an excavation of nine hundred and eighty two thousand and fifty-

[1] Appendix, III.

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eight yards; the whole work involving an expenditure of thirty-two thousand one hundred and forty-eight pounds one shilling and eight pence. The difference between the tides in the two bays is stated to be three hours and a half.

This committee, in concluding their report, say "that the cutting of a navigable canal across the said isthmus is very practicable, and would be a great security to the navigation to and from the southern United States, not only against an enemy, but by affording the means of avoiding the dangers of the shoals in passing round Cape Cod. But as the expense of executing the said canal would be great, and the benefit of it would be general, your committee think it merits the consideration of the Hon. Continental Congress, and therefore humbly propose to your Honors, that when the necessary information is had with regard to the navigableness of Buzzard's Bay to the southerly end of the canal as delineated on the plan, the said plan, or a copy of it, accompanied with every necessary information, should be sent to the Congress for their consideration."

This report was made to the Council August 30, 1776, and then read and sent to the House. In the House of Representatives it was read and ordered to lie on the files of the Court. The Council non-concurred with the House, and appointed James Bowdoin, Esq., with such as the House might join, a committee to take the report into consideration, and report thereon. The House adhered to their own vote, and thus disposed of the subject without further action.

In 1791, a petition was presented to the legislature, praying that a committee might be appointed "to inquire into the practicability, utility, and probable expense of cutting a navigable passage across the isthmus which divides Barnstable Bay and Buzzard's Bay." Upon this petition a resolution was passed on the 11th of March, requesting the Governor "to appoint one or more suitable persons to inquire into the practicability, utility, and probable expense of cutting a navigable canal between Barnstable Bay and Buzzard's Bay, and for that purpose, to survey the isthmus which divides said bays, and to ascertain the elevation of the ground above low-water mark; also, the usual rise of the tides in each bay, and the mean difference of level at high-water, (if any); also, to examine and report the situation of the shoals in Buzzard's Bay, the depth

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of water over them, and the navigability of that bay. The committee appointed under this resolution, consisted of the Governor, Hon. Azor Orne, Thomas Russell, William Sever, and Thomas Davis, Esqrs.

Another resolution, passed May 31, authorized the committee to inquire into the practicability, utility, and probable expense of making a navigable canal between the two bays, at any other place in the county of Barnstable, than across the isthmus; and to survey any place in the county aforesaid, which the Committee thought would probably be most suitable for making such canal, they observing the same directions in the execution of this resolve as were given in the preceding one.

This committee employed James Winthrop and John Hills to survey the isthmus. The report of the former, which exhibited "the elevation of the ground above low-water, the usual rise of the tides in each bay, and the mean difference of level at high-water mark, the situation of the shoals in Buzzard's Bay, the depth of water over them, and the navigability of that bay," cannot be found. The plan made and reported by Mr. Hills, is in the Secretary's Office, and the Committee annex to their Report an "estimate of the expense of making a canal from Barnstable Bay to Buzzard's Bay, conformable" to the said plan. Upon an examination of the plan and the estimates, it appears that the estimates are based upon a canal four rods wide and fifteen feet deep, with three sets of double locks and two floodgates. Its outlet at Buzzard's Bay, was at the mouth of Monumet River, and its route followed the general course of the river to the present village of North Sandwich, near the house of Doctor Bourne; thence, on a straight line, to the swamp, and through the swamp to the head of Scusset River; thence following the general course of the stream, without adopting its bed, to the northerly end of Plymouth Neck, continuing its course to Barnstable Bay. One set of locks was placed at the head of Scusset River, one at North Sandwich, where the canal joins the Monumet River, and the other at Fort Rock in the Monumet. From North Sandwich the canal route was the bed of the river to its mouth at Bourne's Neck, where, as at Barnstable Bay, were flood-gates. The locks were to be thirty feet wide, and one hundred and twenty feet long. The report of the committee is silent upon the subject of a

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supply of water, and in other respects is wanting in details. A deficiency which the report of the engineers, if it could be found, would doubtless supply. It is, however, apparent from what is obtainable of their labors, that the canal from Barnstable Bay to the head of Scusset River, was to be supplied with water from that bay. For the remainder of the distance, (about five miles,) there would seem to be no other source of supply, but from the five ponds in the vicinity, two of which are the source of Monumet River. The plan required two piers on Barnstable Bay, one seven hundred and fifty feet in length, sixty feet wide, and twenty-five feet high; the other, five hundred feet long, forty feet wide, and fifteen feet high. These piers formed a basin which was intended to protect the canal from storms as well as to provide a small harbor for vessels using the same.

The estimated expense of the whole work was seventy thousand seven hundred and seven pounds and ten shillings.

The committee reported that in 1790 six hundred vessels annually passed from the "several districts south of Cape Cod to the districts north of that promontory;" that about two hundred and seventy vessels were piloted from Martha's Vineyard over Nantucket Shoals, at an average expense of twelve dollars each. The committee expressed an opinion that not more than one-half of the coasting vessels would use the canal, as during the winter it would be frozen, and that considerable expense would annually arise in removing the sand driven into the canal by the sea, on the Barnstable Bay pier, and in repairs of the locks and piers. They admit the shortening of the distance and the diminishing of the risk to be one per cent. upon the vessels and their cargo, and think the construction of the canal would increase the commerce between the northern and southern States, and particularly between Massachusetts and the States of Rhode Island, Connecticut and New York. And they submit to the legislature whether the benefits will repay the expense of making the canal and the additional expenditure of keeping it in repair.

It may be pertinent to add at this point, that the mode of construction adopted by the committee in having two levels unaffected by the tide, insured the freezing of the canal during the winter months, while the project of extending into Barnstable Bay the lower pier two hundred and fifty feet beyond the

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upper, would be likely to accumulate sand at the entrance of the basin. The experience of the present day would probably reject both propositions.

Upon this report, the legislature resolved, that it was practicable to make a navigable canal across the isthmus of Cape Cod. That the canal, if made, would be beneficial to the commerce between Massachusetts and the States lying south of it, and that it was reasonable that the canal in contemplation should be made and supported by the commerce which may be carried on by means of the same.

It was further resolved that the legislature would, upon application, authorize any person or persons to construct such canal, and would grant for their benefit a reasonable toll on all vessels and goods that might pass the same, on such conditions and for such time as might be provided.

The secretary was directed to secure and preserve the plan, and to publish the resolves of the legislature in the "Independent Chronicle."

On the first day of March, 1798, James Sullivan and twenty others petitioned the legislature, setting forth that upon a re-examination of the old project of opening a canal from the sea on the north to the sea on the south side of Cape Cod, they were inclined to the belief that the same was practicable on principles and by means which were not formerly thought of. That the great utility and vast advantages resulting from the plan, if carried into effect, were so obvious, that no arguments were necessary to induce the legislature to encourage it, and asking for corporate powers necessary for the undertaking.

An order of notice was passed on the same day by the House, and on the next day by the Senate. This was probably unexecuted; for in June, 1801, the same petition was before the legislature, and a different notice ordered to be given. The records of the legislature contain nothing further in reference to this petition.

On the first of March, 1803, a committee was appointed under an order of the two houses, to consider what encouragement the legislature would hold out to any association of respectable individuals who should effect a practicable navigation for sea vessels from the sea on the south to the sea on the north side of Cape Cod. The legislature adjourned on the 8th day of March,

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and there is no record of any report from this committee, and probably none was made, as the seven days intervening between the appointment of the committee and the adjournment of the legislature was hardly sufficient for the formation of any plan to carry out a project of so much importance.

A glowing description of the benefits and blessings which would flow from the opening of the canal, will be found in a description of Sandwich, written in 1802, and published in the eighth volume of Massachusetts Historical Collections. The writer, after alluding to the repeated public surveys of the route, says: "A more recent survey, which was prompted by the reward of private benefaction, has been made under the direction of Mr. Bachellor, a man of reputed knowledge and experience in works of this nature, which impressed the mind of the undertakers with a favorable idea of its practicability and success. At the time the last survey was taken, the proprietors of the land generally came forward and expressed the disposition to give them to the public towards accomplishing so important an object."

During the last war with Great Britain, the isthmus was frequently used for the transit of merchandise, to avoid capture by the enemy's ships who infested the coast.[1]

In 1818, the project was again revived by citizens of Boston. Israel Thorndike, Thomas H. Perkins, and others, employed Loammi Baldwin to survey the route, which was done, and a plan of the same made, which is deposited in the Bureau of Topographical Engineers in Washington. This Committee have not found any report of Mr. Baldwin, nor have they any information touching the size of the canal or of the locks or gates designed by him, nor of the mode in which the canal was to be supplied with water. A tracing of his plan has been obtained, by which it appears that he designed to locate the southerly end of the canal near the mouth of Back River, and thence running by said river and in close proximity thereto, about one hundred and eighty rods, thence diverging and running to within fifteen rods of Monumet River, at a point about two hundred and forty rods southerly of Monumet Meeting-house; thence running through the valley of the Monumet and on its south-easterly side, to Sandwich, near the house of

[1] History of Cape Cod.

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Doct. Bourne; thence passing over the summit level skirting the south-east side of the Bog Swamp, and cutting the sinuosities of the Scusset below Swift's Mills, it enters Barnstable Bay about one mile north-westerly of the mouth of the river.

This survey gives the highest elevation between the bays thirty-two feet eleven inches and two-tenths; the difference between low-water in Buzzard's and Barnstable Bays, September 11, 1818, eight inches and two-tenths. High-water in Buzzard's Bay five feet rise, and in Barnstable Bay ten feet.

Mr. Baldwin had an opportunity of examining the survey and plan of Mr. Hills, whose northerly route from Dr. Bourne's house to Barnstable Bay he has delineated on his plan. But he does not appear to have adopted any part of his line. The Monumet River bed being wholly avoided by Mr. Baldwin, and the proposed embouchures on Barnstable Bay are nearly a mile distant from each other.

On the 5th of January, 1824, Mr. Lloyd, of Massachusetts, submitted to the Senate of the United States the following resolution:—

"*Resolved*, That the Committee on Roads and Canals be instructed to inquire into the expediency of requesting the President to cause a survey to be made by some duly qualified officer or officers of the engineer or topographical corps, of the best route for opening a navigable communication between Buzzard's Bay and Barnstable Bay; and to report on the practicability of constructing a canal through the isthmus which separates the said bays, of sufficient depth and size to admit vessels of war to pass the same, or the obstacles thereto, and the estimated expense thereof; and on the benefits that would result to the public in time of war, and to the domestic or coasting trade of the United States in time of peace, from the construction of such a canal; which, after the completion of the Chesapeake and Delaware and Raritan Canals, would extend the inland water communication from Albemarle Sound to Massachusetts Bay, passing, in its progress, through the territory or along the borders of ten States."

This resolution was adopted by the Senate on the following day.

On the 24th of January, 1824, the legislature of Massachusetts passed the following resolutions:—

"*Resolved*, That in the present depressed state of our foreign commerce, it is highly important that the coasting trade should receive every



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aid and facility that can be given to it, consistently with the public interest, by opening new communications from port to port, on the sea-coast, and thus rendering the intercourse shorter and more safe than it now is.

"*And whereas*, An opinion is confidently entertained by many (and which has been expressed in a report of the Hon. Albert Gallatin, when Secretary of the Treasury of the United States,) that a communication by a canal from Barnstable Bay to Buzzard's Bay was practicable, and would be highly useful in time of war as well as in peace, in facilitating the intercourse between the Eastern and the Southern and Western States.

"*Resolved*, That the legislature highly approve of the motion made in the Senate of the United States, by the Hon. Mr. Lloyd, of Massachusetts, on this subject.

"*Resolved*, That the senators of this State, in Congress, be instructed, and the representatives be requested, to use their endeavors to obtain a survey, under the authority of the United States government, of Buzzard's Bay and Barnstable Bay, and of the land lying between them, to ascertain the practicability of uniting said bays by a canal adapted to the passage of ships of war as well as of merchant ships and coasters."

After a protracted debate in both Houses of Congress, the following Act, reported to the House on the 15th of December, 1823, finally passed the Senate on the 23d of April, 1824:—

"*Be it enacted, &c.*, That the President of the United States is hereby authorized to cause the necessary surveys, plans and estimates to be made of the routes of such roads and canals as he may deem of national importance, in a commercial or military point of view, or necessary for the transportation of the public mail; designating, in the case of each canal, what parts may be made capable of sloop navigation: the surveys, plans and estimates, for each, when completed, to be laid before Congress."

Section 2 authorized the employment of engineers and made the necessary appropriation for carrying on the work. Under the foregoing Act of Congress and in accordance with instructions drawn up by the Board of Internal Improvement, the ground between Barnstable and Buzzard's Bay was surveyed under the direction of Major P. H. Perault, of the United States Topographical Engineers, in 1825; a general examination of the country between the two bays having been made the previous year. Two routes were explored; one from Barnstable Harbor

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to Hyannis Harbor; the other following the valleys of the Monumet and Scusset Rivers. The former is stated to be from five to six miles in length, but for reasons given in the report, it was considered inferior to the latter, which alone was surveyed.

Pending this survey, resolutions were, upon the report of a committee, introduced to the legislature, authorizing the governor to appoint an agent or agents to accompany and assist the engineers and to transmit to the governor copies of such plans and surveys as might be made of the route, together with such examinations and estimates of the expense of the work as might be judged expedient towards accomplishing the object of the legislature, &c. The resolutions were so amended in the Senate as to embrace other surveys on Connecticut River, and on being returned to the House were referred to a select committee, who reported a substitute for the amended resolves. The substitute was referred to a new committee, which, on the 18th of June, 1825, reported that it was inexpedient to legislate further upon the subject, and this report was accepted.

The whole subject was, however, very carefully considered by the engineers of the United States and subsequently by the Board of Internal Improvements. The survey and plan was completed in 1825, and in accordance with the Act authorizing it, was laid before Congress in February, 1826. The plan and estimate of the canal were drawn up by the Board of Internal Improvement, in 1829, in conformity with a resolution of Congress, passed January 2d, 1827.

This survey is, in most of its features, identical with that made by Mr. Baldwin in 1818. Commencing at Back River Harbor, the canal route runs by that river a short distance, thence diverging, it strikes the valley of the Monumet some rods south-westerly of the point proposed by Mr. Baldwin; thence on the south-easterly side of the Monumet and Scusset Rivers, following the general course of Baldwin's survey, to Plymouth's Neck; thence, with the exception of a slight angle, direct to Scusset Harbor. An experimental line from Swift's Mill to Barnstable Bay (perhaps identical with Mr. Hills' survey in 1791,) is also delineated upon the plan.

With this survey before them, the Board of Internal Improvements revisited the ground in 1828 and in their report adapted

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to a route for the canal, the line of levels found by the survey. The report finds generally, that "the depression of the ground through which run the Monumet and Scusset Rivers, presents the best relative facilities to connect the two bays." That "the ground is generally a compound of sand and clay, embedding loose stones and gravel," while some parts of it "are marshy." That "the summit point of the ground extending from one bay to the other, in the direction of the canal route, is 34 feet $7\frac{3}{10}$ inches above low tide in Buzzard's, or 35 feet $6\frac{6}{10}$ inches above low tide in Barnstable." That "the most convenient site for the termination of the canal into Buzzard's Bay is Back River Harbor." And that the location of the eastern end should be at a point about one mile north of the mouth of the Scusset River, thus adopting, at the Barnstable side, the experimental line in Major Perault's survey and the practical line in Mr. Hills' survey. The line adopted by the Board gives the distance from Buzzard's to Barnstable Bay eight miles five hundred and twenty-four yards, measured between the falls of the regulating locks.

The canal proposed by the Board was to be 36 feet wide at the bottom, 60 feet on the water line, 8 feet deep, with a tow-path 9 feet wide and 3 feet above the surface of the canal. At each end of the canal it was intended to have a basin 96 feet wide at the bottom and 120 feet on the water line. The western basin to be 440 yards long, the eastern 970. Four modes of construction were discussed in the report.

1st. With an upper level 2 miles long, the bottom of which would be 8 feet above low tide in Barnstable.

2d. With an upper level $6\frac{7}{8}$ miles long, the bottom of which would be 8 feet above low tide in Barnstable.

3d. With an upper level $6\frac{7}{8}$ miles long, the bottom of which would be 4 feet above low tide in Barnstable.

4th. With a single level 8 miles 524 yards long, the bottom would be on the level with low tide in Barnstable.

A canal constructed according to the first, second or third plan, was to be filled by water from Herring Pond; upon the fourth plan, the canal was to be filled by water from Barnstable Bay.

The Board recommended the adoption of the third mode of construction, yet in view of the possibility that Herring Pond

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might be drained in excavating for the canal, the plan reported by them was based on the fourth hypothesis, and its expense was stated at $669,522. In this calculation the locks were to be 107 feet long and 26 feet wide. It was assumed, at the time, that a canal sufficient for vessels carrying 130 tons and allowing of 36 passages per day, would fully meet the exigencies of the coasting trade, for which the canal was mainly designed.

The report fully examines all the practical questions bearing upon the subject of a channel across the isthmus, contains schedules and estimates of the work necessary under either of the modes of construction discussed therein, and without deciding upon its necessity, estimates the cost of lining the canal with a dry wall at $58,416. This report, with the survey, has been printed by the legislature and may be found in "Public Document, No. 34, for the year 1860." It is unnecessary to make from it any recital except the following extract, giving the results of observations upon the tides, made during the month of July, 1825.

"The stages of high and low tide in Buzzard's, precede, respectively, by a mean of three hours, the similar stages in Barnstable."

"The highest rise of tide in Buzzard's has been 6 feet 9 inches, for one day only; the rise has been 5 feet for 20 days, and a little more than 4 feet for 10 days. Common tide 4 feet 8 inches."

"Twelve feet for two days has been the greatest rise in Barnstable; for 7 days the rise has been 11 feet; for 18 days 10 feet; for 4 days 9 feet. Common tide 10 feet."

"The plane of low tide in Buzzard's is $11\frac{3}{10}$ inches above the plane of low tide in Barnstable."

A plan to accompany this report was prepared by the Board, which conforms in its general features to that made by Major Perault. It is, however, more full in its details, varies the embouchure at Buzzard's Bay, and in approaching Barnstable Bay it adopts a more northerly course to avoid the low ground near the Scusset River and shows an extensive basin at each end of the route.

This report of the Board of Internal Improvement was printed by order of the House of Representatives, February 8, 1830. No further action appears to have been taken upon

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it, which may be explained by the fact that the result of the presidential election in 1828 changed the policy of the general government upon the subject of internal improvements.

Incidental to this history of the proceedings touching the proposed canal, may be mentioned the fact that, contemporaneously with the survey made by Major Perault, Congress ordered a survey to test the feasibility of connecting the waters of Boston Harbor with those of Narraganset Bay by a canal still farther inland. With this idea two routes were surveyed; one beginning at Weymouth Back River, which divides Weymouth from Hingham, and passing through Weymouth, a corner of Hingham, Abington, East Bridgewater to Fitaquit Bridge in Middleborough, thence through Middleborough and Taunton to Assonet Bay, on Taunton Great River, about eight miles below Taunton village. The summit level on this route is in Abington. The other being the westerly route, began at Weymouth Fore River and passed through the towns of Braintree, Randolph, North Bridgewater, West Bridgewater, Bridgewater and Raynham to Taunton Great River in Taunton, the summit level being at Howard's Meadow, in Randolph.

Agents on behalf of the Commonwealth attended on this survey, but the researches of the Committee have failed to discover that any action was taken upon it by the government at Washington. Messrs. Minot Thayer and Benjamin Hobart, agents for the Commonwealth, reported their doings. The report was submitted to the legislature, and referred to the Committee on Railways and Canals, who February 26, 1829, made a report thereon, calling for the report of the engineer, and accompanying papers.

In 1826, the legislature, by resolution, requested the governor to procure from the secretary of war copies of the surveys made by order of the general government in the county of Barnstable, touching the proposed canal between Buzzard's and Barnstable Bay, with copies of the communications of the board of engineers upon the same subject. And in 1829, as above stated, a similar request was made to him to apply to the same source for a copy of the report of the engineers who made surveys for a canal route from Boston to Narraganset Bay, with the plans, maps and estimates supposed to accompany the same.

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In 1830, the governor communicated to the legislature a copy of the report of the survey across the isthmus of Cape Cod, with the plan and details of the proposed canal, drawn up by the board of internal improvement, under a resolution of Congress, and recommended that they be deposited in the library. The recommendation was adopted. No report of the survey of the route to unite Boston with Narraganset Bay was submitted, and it is supposed none was received.

The Committee are not aware that from 1830 the proposed canal received any public attention till the subject was proposed by the governor in 1860, in his message to the legislature. The recommendation of the governor was referred to a joint committee, who by Mr. Amos B. Merrill, their chairman on the part of the House, made an able and elaborate report, which concludes as follows:—

"Upon a full consideration of all the matters committed to them, the committee are of opinion that the construction of a ship channel or canal, with the requisite harbor improvements, at or near the points proposed, of capacity ample to satisfy the entire coasting trade of the United States, is a practicable enterprise, quite within the range of this class of improvements; that when constructed it will become the thoroughfare of the coasting trade, shorten distance, save life and property, and materially reduce the cost of transportation; that the cost of construction will not be excessive, but will fall far below its value to navigation when constructed; that, while it will benefit all the Atlantic States engaged in or connected by the coasting trade, and ought therefore to be an object of common interest to all, and to the Federal Government, yet it is the duty of Massachusetts, especially, within whose territory the proposed route lies, and whose progress it will greatly promote, to take the initiative, and make all examinations and investigations necessary to establish the practicability and value of the improvement.

"This may be best done, in the opinion of your committee, by a joint special committee of both branches of the legislature sitting in the recess, with full authority to employ engineers, make surveys and soundings, collect statistics, examine localities, and modes of construction, and report the same, with plans and estimates, for a sufficient ship channel or canal on the best route through the isthmus of Cape Cod, to the next legislature.

"Your committee would further say, that this course meets the views of the committee of the Boston Board of Trade, with whom they have

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conferred, and that the Board will coöperate in this work with any committee which the legislature may appoint."

The foregoing is a short history of the isthmus of Cape Cod, in connection with its use as a place of transit for merchandise by the inhabitants of Plymouth Colony, and with the various efforts which have been made to unite at that point the two bays by a navigable canal. The advantages of such a communication will be readily conceded. And the above recited proceedings of individuals, of the legislature, and of Congress, indicate the existence of a belief in the necessity and practicability of the undertaking.

The report presented by Mr. Merrill was accepted by the legislature, and a resolution in accordance with the report was adopted April 4, 1860, under which this Committee was appointed. The resolution directs the Committee to make examination of localities, to prosecute surveys and soundings, collect statistics, and do all other things necessary to enable them to determine upon the practicability of constructing a canal upon the best route therefor, and also to report its cost and form of construction, together with its value to commerce, and the means by which it should be constructed, with all other matters necessary to form a judgment on the same.

In view of the advantages directly accruing to the commercial interests of the country by the construction of the proposed canal, the Committee were led to the conclusion that a large portion of its "means" of construction should be furnished by the United States; and that, in order to make the survey available, as the foundation of an application to Congress to aid in constructing the work, it might be essential to interest the general government in the proposed surveys. In order to effect this object, a letter was addressed to the Superintendent of the United States Coast Survey, transmitting the report and resolution of the legislature upon this subject, and asking his opinion and advice concerning the route of the canal heretofore proposed, the necessary qualifications for an engineer to be employed, the adaptability of the existing coast survey chart for the use of the Committee, and also if the Commissioners of the United States on Boston Harbor (of which he was one) would aid the Committee in their explorations and investigations touching

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the route, the surveys, and the necessary soundings for the said canal. An answer was received from that officer, expressing his interest in the undertaking, and his readiness, and that of General Totten, one of his colleagues, to assist the Committee so far as they could consistently with their public engagements. He added, that additional surveys and soundings would be necessary, which might be performed advantageously for the State, by the officers of the Coast Survey, who would be employed a portion of the summer in Boston Harbor. This correspondence was communicated to Captain Davis, the other commissioner, who being in Boston, was present at a meeting of the Committee, and gave to them his views upon the subject, and expressed a readiness to aid with his colleagues in the undertaking, so far as his public duties would allow.

Application was then made to the President to permit the Commissioners to render the assistance desired, which application was granted.

Before commencing a survey, the Committee personally explored and examined the isthmus, and the coasts adjacent thereto, in both bays, and having, in concert with said Commissioners, determined to survey the route heretofore selected as well by public opinion as by the State and National legislatures, as the most suitable for the proposed canal, they availed themselves of the proposal of Professor Bache, and employed for that purpose the officers of the coast survey. By this arrangement, engineers of the highest rank were obtained, at a moderate expense.

After making the necessary surveys, soundings and observations, these officers prepared and completed the following maps:—

First. A Topographic Map of the entire valley of the Monumet and Scusset Rivers, on a scale of $\frac{1}{10000}$, about six and a half inches to the mile, upon which the horizontal curves are drawn at every five feet of elevation, and referred to points upon the railroad, by Sub-Assistant W. H. Dennis, U. S. C. S.

Second. A Map of the north-east part of Buzzard's Bay, included between Monumet and Tempe's Knob Necks, and the approaches, by Lieut. George S. Blake, U. S. N., Assistant U. S. C. S.



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Third. A Map of Barnstable Bay, from three-quarters of a mile south to one and three-quarters of a mile north of the mouth of Scusset River, by Lieut. J. Wilkinson, U. S. N., Assistant U. S. C. S.

Fourth. Soundings in Buzzard's Bay. The hydrographic sheet shows the soundings in both bays, reduced to mean low water, and on a scale corresponding with the topographical map.

Fifth. Records of a series of tidal and current observations in Buzzard's Bay and in Barnstable Bay, and of investigations on drifts, with tables, diagrams and maps accompanying the same, by Assistant H. Mitchell, U. S. C. S. A full copy of this record will appear in the Appendix, V.

The topographical map prepared by Mr. Dennis embraces an area of about four and a half miles of finished work, with six and one-eighth miles of shore line, twenty-seven miles of roads, including the Cape Cod Railroad, and twenty-three and a half miles of creeks, rivers and ponds; the horizontal contour lines drawn on the basis of a line of levels on the railroad running through the valley, represent the elevations at every five feet, and the map shows the general features of the country in minute detail. The valley surveyed is seven and three-quarter miles from shore to shore, and in a direct line from the waters of Buzzard's Bay to Barnstable Bay, six and seven-eighths miles. The general direction of its course is north-east and south-west, and bounded by two ranges of hills, varying from sixty to one hundred and eighty feet in height. At its narrowest part, four miles from Back River Harbor, it is two hundred and twenty yards wide, and it gradually expands from this point in both directions.

The bottom of the valley rises regularly to a height of twenty-five feet and a few inches, the greatest elevation being at a place distant five miles from Buzzard's Bay; from this point it descends to Barnstable Bay, where it is two feet higher than at Buzzard's. The soil is mainly gravel, and easy of excavation. At the south-west end of the valley is the village of Monumet, with about two hundred inhabitants. Near the middle is the village of North Sandwich, with about seventy-five inhabitants, and at the north-east end is Scusset or West Sandwich, with one hundred and fifty inhabitants. With the exception of three-quarters of a mile, the valley is watered by

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two streams, Monumet and Scusset Rivers. The former takes its rise in the village of North Sandwich, whence it flows from a small pond into which the water of Herring Pond empties itself. Its course is winding for a distance of four and three-quarter miles, and debouches into Buzzard's Bay about one mile westward of Back River Harbor. Its banks are generally marshy, and its average depth above Monumet Bridge about three feet. Herring Pond has an area of about three miles, and is about twenty feet above high water. There are numerous springs emptying into Monumet River, and tide water extends up its course about three and a quarter miles. The highest part of the valley is nearly midway between the two rivers.

Scusset River, about three-quarters of a mile from Monumet River, takes its rise in an artificial pond, formerly a boggy marsh; it forms another pond at West Sandwich, which is ten feet above Buzzard's Bay, and of an average depth of three feet. Thence it meanders through a marshy tract, covering an area of about one square mile, where it receives two principal branches, which are fed by creeks and ditches, being themselves for the most part supplied by springs. The river empties into Barnstable Bay through a narrow ridge of sand, which separates the bay from the marsh. Its mouth continually works to the south-east, until it reaches the firm land near Sandwich, and then closes—the marsh becomes flooded, and the river breaks out again through the sand ridge some distance above its present mouth; and the process of working down the coast is again renewed. This shifting process is said to occupy about fifty years. The river broke through the sand ridge in 1823, and is now working to the south-east. The explanation of this phenomenon is, that the shingle strewn along the bay-shore is set in motion by the storms, and the sea on such occasions impinging obliquely upon the beach, the stones and sand are driven to the southward, and finally, with the aid of a point of rocks projecting into the sea near Sandwich, closes the mouth of the river. The depth of mouth of the Scusset is varied by the tides and winds. It is often fordable at low water. The tide flows through the entire marsh to the first pond in West Sandwich, a distance of three miles.

When the surveys and observations had been completed, the season was so far advanced, that the services of the greater

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portion of the Coast Survey force could not be had for a continuous prosecution of the work, in consequence of other engagements; and the stay of the Commissioners could not be prolonged for a similar reason. At this time the cross-sections had not been surveyed; the soundings of the two rivers had not been completed, nor had any progress been made in locating the specific route for the canal, and consequently no basis for an estimate had been formed.

In the frequent conferences between the Commissioners and the Committee, the capacity and mode of constructing the proposed canal were discussed, as well as the necessity for, and dimensions of, break-waters for Barnstable Bay, and the propriety of constructing locks at the termini of the canal. The result of these conferences was an understanding that the necessities of the navigation to be benefited by its construction would require a canal at least one hundred and fifty feet wide and eighteen feet deep, with a lock at each outlet. The canal to be filled with water from Barnstable Bay, and the water to be maintained in the canal as near as possible to the elevation of high-water in the bay. It was also understood that the Committee would proceed in the work, employing a competent engineer of the first class, with suitable assistants, to complete the same, and the Commissioners signified their readiness to revise or examine the plans and calculations thereafter to be made, and to give their advice in any part of the construction.

Soon after the Commissioners reached Washington, they transmitted a full report[1] of their doings in the premises, accompanied by the maps, charts and records of observations already described. In this report the whole subject of the canal is fully and ably discussed, and the paper abounds in suggestions of the highest practical importance, bearing upon the preparation for, as well as the construction of, the canal, from which the Committee as well as the engineer and assistants subsequently employed have derived much valuable information.

In pursuance of the arrangement with the Commissioners, Mr. George R. Baldwin was engaged to superintend the unfinished surveys and soundings, and also to decide upon the best mode of constructing the canal and the locks and break-waters neces-

[1] Appendix, IV.

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sary to be connected therewith, and to designate the most suitable location for the entire work, and also to report, accompanied by plans and estimates of the cost of completing the same. In this service he was to be assisted by Messrs. J. G. Chase and W. F. Durfee, who were at the time of Mr. Baldwin's engagement employed upon the soundings. The report of the commissioners, with the accompanying papers, was placed in the hands of Mr. Baldwin, who with his assistants were engaged in the performance of their assigned duties in March, 1861, when the legislature passed some additional resolves upon the subject of the proposed canal, making further provisions for the completion of the undertaking, and appointing a new committee to take charge of the operation.

Under the superintendence of the second committee the work has been successfully prosecuted and completed. A finely executed topographical map of the entire valley[1] has been executed by Mr. Chase, which presents—

The general features of the valley;

The proposed canal, as located by Mr. Baldwin;

A profile of the same, with the necessary soundings in both bays, the latter taken from the coast survey charts;

A line of dredging at each extremity of the canal;

A plan of the several break-waters, with cross-sections of each;

A plan of the locks and the sluice at Barnstable Bay, with longitudinal and cross-sections of the same;

Parts of Buttermilk Bay and Herring Pond;

A reduced plan of Cape Cod and Barnstable County, exhibiting the general outline of the bay.

The cross-sectional surveys made by the same gentleman have been carefully preserved, and will be deposited with the other plans and documents appertaining to the project.

In locating the canal, Mr. Baldwin has taken Back River Harbor for its south-western terminus, following the plan of previous engineers, excepting Mr. Hills. From this point the line runs N. 19° 31′ E., and extends $3{,}165\frac{91}{100}$ feet; thence by a curved line more easterly, the radius of which curve is 3,000 feet; 1,000 feet to Monomet River, and thence continuing by

[1] Appendix, VII.

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said curve $2{,}302\frac{16}{100}$ feet; thence tangent to the last named point and N. 82° 35′ E. $4{,}100\frac{53}{100}$ feet to a point on the northerly side of the bridge over Monomet River at Monument; thence by a curved line more easterly tangent to said last named line $4{,}346\frac{30}{100}$ feet, the radius of which curve is 11,371 feet; thence tangent to the same and N. 60° 41′ E. 2,058 feet; thence more northerly by a curve whose radius is $5{,}729\frac{86}{100}$ feet, tangent to said last named point $2{,}110\frac{94}{100}$ feet; thence tangent to said curve N. 39° 34′ 30″ E. $2{,}115\frac{28}{100}$ feet; thence tangent to said last line by a curve the radius of which is $7{,}239\frac{60}{100}$ feet, and more easterly 1,100 feet to the easterly side of "Axe Factory Pond," and at or near the head of tide-water in Monomet River; thence the line departs from said river and continues by the same curve last described $5{,}090\frac{34}{100}$ feet; thence by another curve in the same direction tangent to the last from the point last named, the radius of which curve $9{,}046\frac{88}{100}$ feet, and running $2{,}588\frac{26}{100}$ feet; thence tangent to said last curve S. 75° 02′ 30″ E. $2{,}931\frac{81}{100}$ feet to a point which is easterly about 800 feet from where the line first touches upon waters which form the source of the Scusset River; thence by a curved line more northerly, the radius of which curve is $2{,}678\frac{22}{100}$ feet tangent to the last named point following the Scusset River and valley, passing over the "Gravelly Hole," so called, to and over the salt marshes $3{,}764\frac{91}{100}$ feet, to a point on the northerly bank of Scusset River, near "Sagamore Hill;" thence tangent to said last named point N. 24° 24′ 47″ E., crossing the westerly side of said Sagamore Hill, the salt marshes and Scusset and Bass Rivers, $3{,}983\frac{81}{100}$ feet, to the head of the lock as located at the easterly termination of the canal at Barnstable Bay. The highest point of land attained on this route is $27\frac{193}{1000}$ feet above the bench of the U. S. Coast Survey in Back River Harbor, standing $4\frac{76}{100}$ feet above mean low water. It is a little easterly from the village of North Sandwich, and about 1,000 feet from the point of divergence hereinafter to be stated. The length of this line is $7\frac{663888}{1000000}$ miles, and is denominated in Mr. Baldwin's report the "Sagamore line." It conforms in its general course to the line surveyed by Mr. Hills, in 1791, and that adopted by the Board of Internal Improvement, 1829. It differs from Mr. Hills', in having for its south-western terminus Back River Harbor, and from that of the Board of Internal

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Improvement, in using three or four miles of the Monumet River for the bed of the canal.

With a view of shortening the length of the canal, a more westerly line from the head waters of the Scusset River has been surveyed. This line diverges from the main line at a point upon the last part of the compound curve therein named, which is 600 feet easterly from the first tangent of the last part of said curve; thence by a reverse curve northerly tangent to the point of departure, and on a radius of $3{,}081\frac{83}{100}$ feet, extending by said curved line 2,626 feet; thence tangent to the termination of said reverse curve, and N. 43° 33′ 53″ E. $3{,}539\frac{28}{100}$, to a point at the head of the deep valley making westerly from the Scusset marshes into the adjacent highlands; thence by a curve more easterly tangent from the last named point, the radius of which curve is 3,000 feet, running $1{,}458\frac{73}{100}$ feet; thence tangent from said curve N. 71° 22′ 37″ E. 3,147 feet, to the head of the lock as located upon Barnstable Bay, at a point northerly on said shore 1,513 feet from the termination of the line first described. The summit level of this line is $65\frac{398}{1000}$ feet above the bench in Back River Harbor, and $70\frac{158}{1000}$ above mean low water at the same place, while the highest point attained on the Sagamore line is $31\frac{953}{1000}$ feet above low-water in Buzzard's Bay, and $34\frac{473}{1000}$ feet above mean low-water in Barnstable Bay. The length of the canal upon this line, which is denominated by Mr. Baldwin the Scusset line, being $7\frac{27168}{100000}$ miles. It is $2{,}070\frac{82}{100}$ feet shorter than the main or Sagamore line.

In giving the length of the canal the measurement is made from the head of the locks. The distance from low-water in Buzzard's Bay to low-water in Barnstable Bay is, on the Sagamore line, $7\frac{73528}{100000}$ miles; and on the Scusset line, $7\frac{398}{1000}$ miles.

It is essential to the proper understanding of this work, to state that the south-eastern portion of Massachusetts is the scene of an interference of two branches of the tide wave, which meet and interfere at the south shore of Nantucket and the "West Chop" in Vineyard Sound. These waves vary considerably in size. They are supposed to have a common mean level, that is, they rise and fall above and below a common plane. The tides for the two bays differ in time 3 h. 23 m. for high, and 4 h. 11 m. for low water. The tide of Buzzard's Bay being the earlier. The mean range of Back River Harbor is less than half that of

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Barnstable Bay. The former being in July and August, 1860, 4 feet 11, the latter 9 feet 17. But the former is more irregular. The duration of the rise and fall for Barnstable Bay is nearly equal; the rise being 6 h. 14 m., the fall 6 h. 11 m. That of Back River differs about one hour and a half; the rise being 7 h. 1 m., the fall 5 h. 23 m. The maximum difference of height between the two bays, the one occurring on the flood, the other on the ebb, are not equal. The rapid fall of the tide in Back River Harbor causes low-water to occur in this basin soon after high-water in Barnstable Bay. On the other hand, high-water being delayed at the former place, does not occur until the tide in Barnstable Bay has risen considerably. Barnstable Bay, at certain periods, stands nearly eight feet above Back River Harbor, while the latter never attains a height much exceeding six feet above the former. The mean of the results is 4.66 feet for maximum height of Back River Harbor above Barnstable Bay, and 5.79 for the reverse relations of these basins. It is evident from this relation of water heads that the currents which would traverse a free canal connecting the two bays would be unequal, and of considerable force, that running to the westward would have the greater velocity and the shorter duration.

To unite waters whose rise and fall are so varied and irregular, by a canal of only about seven miles in length, would, perhaps, under any mode of feeding, require at its termini locks and gates. And their necessity will be still more apparent under the plan adopted for this work, which is to feed the canal from Barnstable Bay, and to maintain the water therein as near as may be to a level with mean high water in that basin.

In view of the peculiarities of the valley, the action of the tides, and the assumed necessities of commerce seeking this route, the engineer has designed a canal with a lock at each end, 556 feet long, 96 feet wide; a basin at Back River Harbor 1,500 feet long and 252 feet wide; a basin at Barnstable Bay 500 feet wide, with a length depending upon the particular terminus adopted there. The Scusset route requiring a length of 1,000 feet, and the Sagamore route 1,300 feet. The size and form of the proposed canal has been based upon the idea of allowing the largest side-wheel steamers to pass each other at all points therein.

Its dimensions are as follows:—

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| | |
|---|---|
| Width at bottom, | 120 feet. |
| " " 10 feet above bottom, exclusive of berms, | 150 " |
| " " 10 feet above bottom, including berms, | 180 " |
| " " 18 feet above bottom, at water line, | 204 " |
| " " 24 feet above bottom, exclusive of tow-path, | 220 " |
| " " 24 feet above bottom, including tow-path, | 250 " |

By leaving the submerged berms of 15 feet wide, much excavation is saved without incommoding the large steamers.

To obtain a shelter for vessels using the canal, three breakwaters are proposed in Barnstable Bay, to be built of rubble stone, surmounted by a cut-stone wall laid in hydraulic cement.

| | |
|---|---|
| The eastern or inner breakwater on the Sagamore route, is | 2,050 feet long. |
| On the Scusset route, it is | 2,515 " " |
| " western route, it is | 4,680 " " |
| " outer route, it is | 5,281 " " |

In addition to which are three pier wharves, two of which are 40 feet wide and 200 feet long, and the other 1,630 feet long. Each breakwater is furnished with a stone beacon, and a lighthouse is provided for the western head of the outer one. The construction of the outer breakwater is upon the arc of a circle, the radius of which is 3,975 feet. Its western head is 1,300 feet from the head of the western breakwater, and its eastern head is 3,150 feet from the head of the inner breakwater. The three form a capacious and safe basin for vessels using the canal, and a harbor of refuge for the navigation of Barnstable Bay in case of storms. The depth of water in the harbor is sufficient for ships of the largest class, and it could be made in storms that would render the harbor of Provincetown inaccessible.

Plans and sections of the locks, feeding sluices and breakwaters, are given upon the plan, and Mr. Baldwin's report[1] contains detailed statements fully setting forth the nature of the work, the mode of construction, the materials to be used,

[1] Appendix, VI.



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and the obstructions and facilities apparent in the geological formation of the valley.

In addition to the above described constructions, the plan adopted contemplates the dredging of a channel 600 feet wide from Wenaumet Neck to Back River Harbor; dredging out the harbor, and building a wall to preserve the channel from the lock to Stony Point; and dredging a channel from the lock and sluice to deep water in Barnstable Bay.

Should a canal be constructed upon the location described above, it will be necessary to change the location of the Cape Cod Railroad in the manner and to the extent specified in Mr. Baldwin's report, and also to change in several places the course of the highway running easterly from the Mill at Monument to West Sandwich, along the southerly side of the valley.

The cost of constructing the canal upon the Scusset line, to contain eighteen feet of water, in accordance with the details above set forth, including the locks, sluices, basins, harbors, breakwaters, and the dredging to deep water in the bays, as shown on the map of surveys made by Mr. Chase, is as follows:

| | |
|---|---|
| Dredging from Wenaumet Neck to the lock at Back River Harbor, and sea walls, | $409,190 77 |
| Cost of lock at Back River Harbor, | 742,764 72 |
| Cost of revetment wall along west side of canal basin at Back River lock, including the wing walls at head of lock, | 62,916 40 |
| Cost of changing the Cape Cod Railroad at Monument and North Sandwich, | 112,190 12 |
| Cost of sluice-way for admitting Herring Pond, | 4,739 44 |
| Cost of Scusset lock and sluice, | 1,094,912 82 |
| Cost of revetment wall along west side of canal basin, extending from wing wall to sluice 1,045 feet, | 75,240 00 |
| Cost of three pier wharves, 2,030 feet, | 50,304 00 |
| Cost of inner breakwater, | 434,407 90 |
| Cost of excavation for canal, | 1,345,353 90 |
| Cost of dredging channel to deep water in Barnstable Bay, | 17,775 75 |
| Cost of land and buildings taken for the canal, | 60,000 00 |
| Cost of western breakwater, | 1,893,171 84 |

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| | |
|---|---|
| Cost of outer breakwater, . . . . | $2,690,328 05 |
| Cost of superintendence and contingencies, 10 per cent., . . . . . | 901,329 47 |
| Making a total of . . . . . | $9,914,625 18 |

If instead of the Scusset line the Sagamore line should be adopted for the line of the canal, the cost of the whole will be as follows:—

| | |
|---|---|
| Cost of constructing canal locks and breakwaters as in estimate for Scusset line, omitting items of excavation and land damages, . . . | $7,607,940 81 |
| Cost of excavation for trunk of canal across the Cape, *via* West Sandwich and Sagamore Hill, including two canal basins, . . . . | 1,018,459 20 |
| Cost of land required for canal, exclusive of buildings, . . . . . | 45,650 00 |
| Cost of houses and mill-power, . . . . | 17,000 00 |
| Superintendence and contingencies, 10 per cent., | 868,905 00 |
| Total cost for Sagamore line, . . . | $9,557,955 01 |

The foregoing details and estimates are designed for a work that would provide full and entire accommodation for all the navigation that will seek a transit through the canal, and are supposed to be adapted to render the same as thorough and permanent as the present state of engineering science can assure.

It is apparent that a canal of less width than the one above proposed might accommodate the wants of commerce for many years, and that the dredging and breakwaters might be reduced without materially lessening the convenience and protection they are designed to afford.

The following estimate of a canal reduced in width one-third, with the lines of dredging reduced to 300 feet wide, and the length of the outer breakwater reduced one-half, to 2,640 feet, is based upon the same general mode of construction, leaving the locks, gates, and the manner of operating the latter, the same as in the foregoing table:—

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|---|---|
| Dredging channel in Buzzard's Bay and in Back River Harbor, 300 feet wide, revetment walls at north and north-east side of Back River Harbor, | $187,500 00 |
| Cost of lock at Back River same as first estimate, | 762,764 72 |
| Revetment wall along west side of canal basin at head of lock, | 20,000 00 |
| Changing railroad and common road at Monument and North Sandwich, | 112,190 12 |
| Sluice-way at North Sandwich, | 4,739 44 |
| Lock and sluice at Scusset, same as first estimate, | 1,094,912 82 |
| Revetment wall west side basin at Scusset, | 20,000 00 |
| Three pier wharves, 2,030 feet, | 50,304 00 |
| Inner breakwater, | 434,407 90 |
| Excavation for canal, *via* Deep Cut, two-thirds of first estimate, | 896,902 50 |
| Dredging channel in Barnstable Bay, 300 feet wide, | 8,500 00 |
| Damages for land, buildings, and mill power, per first estimate, | 60,000 00 |
| Western breakwater, per first estimate, | 1,893,171 84 |
| Outer breakwater, omitting half its length, | 1,300,000 00 |
| Light-house on outer breakwater, | 20,000 00 |
| Superintendence and contingencies, 10 per cent., | 686,539 33 |
| Total, | $7,551,932 67 |

The above shows the cost of the canal, if located on the Scusset line, reduced as above stated. If the Sagamore route be adopted, the cost of the entire work upon the same plan of construction will be as follows:—

| | |
|---|---|
| Cost of canal by Scusset line, omitting earth excavation and damages, | $5,908,490 84 |
| Excavation for canal, *via* West Sandwich and Sagamore Hill, two-thirds of first estimate, | 678,972 90 |
| Damages for land, buildings, and mill-power, | 62,650 00 |
| Superintendence and contingencies, 10 per cent., | 664,011 37 |
| Total, | $7,314,125 11 |

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Following the suggestion of the U. S. Commissioners, the Engineer has computed the cost of the necessary breakwaters by using grillage for their base, with rubble stone for the body of the work. In this computation the outer breakwater is dispensed with, and the western extended 1,500 feet. The plan gives the harbor in Barnstable Bay but one entrance, diminishes its capacity to some extent, and increases perhaps its safety. The cost of the work upon both modes of construction, using the grillage base for the breakwaters, and dispensing with the outer breakwater, will appear below:—

*Inner Breakwater.*

| | |
|---|---|
| Excavation for grillage from lock to deep water level, with lock invert, | $4,473 31 |
| Grillage for base, | 53,486 40 |
| Rubble-stone for body of breakwater, | 281,047 48 |
| Cut stone parapet wall along top of breakwater, | 43,285 80 |
| Cut stone conical beacon, | 500 00 |
| Extra work paving top of breakwater, | 1,290 96 |
| Wooden pier wharf, as in former estimate, | 40,750 00 |
| Rubble-stone for breakwater without grillage, along the easterly side of lock, as per former estimate, | 14,787 15 |
| Cut stone parapet along same part, | 9,963 00 |
| Total cost of inner breakwater, | $449,584 10 |

*Western Breakwater.*

| | |
|---|---|
| Grillage for base of breakwater, | $141,597 84 |
| Rubble-stone for body of breakwater, | 689,700 06 |
| Stone beacon for head of breakwater, | 500 00 |
| Add cost for extending this breakwater 1,500 feet as a substitute for the outer breakwater shown on the map at unit cost in 6 fathoms, 1,500 at 310 per foot, | 465,000 00 |
| | $1,746,382 00 |
| Superintendence and contingencies, 10 per cent., | 174,638 20 |
| | $1,921,020 20 |

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This change in the mode of constructing the breakwaters very materially reduces the cost of the canal.

| | |
|---|---|
| By the first estimate, the cost of the work on the Scusset line is . . . . . | $9,914,625 18 |
| Deduct estimated cost of breakwaters, . . | 5,564,523 56 |
| | $4,350,101 62 |
| Cost of breakwaters by 2d mode of construction, | 1,921,020 20 |
| Cost of canal according to first plan with breakwaters on grillage base, . . . . | $6,271,121 82 |
| By the same estimate the cost of the work on the Sagamore line is . . . . . | $9,557,955 01 |
| Deduct estimated cost of breakwaters, . . | 5,564,523 56 |
| | $3,993,431 45 |
| Add cost of breakwater by second mode of construction, . . . . . | 1,921,020 20 |
| Cost of canal according to first plan, with breakwater on grillage base, . . . . . | $5,914,451 65 |
| By the second estimate the cost of the work on the Scusset line is . . . . . | $7,551,932 67 |
| Deduct estimated cost of breakwaters, . . | 4,057,716 51 |
| | $3,494,216 16 |
| Add cost of breakwaters by second mode of construction, . . . . . | 1,921,020 20 |
| Cost of canal according to the second plan, with breakwaters on grillage base, . . . | $5,415,236 36 |
| By the same estimate the cost of the work on the Sagamore line is . . . . . | $7,304,125 11 |
| Deduct estimated cost of breakwaters, . . | 4,057,716 51 |
| | $3,246,408 60 |
| Add cost of breakwaters by second mode of construction, . . . . . | 1,921,020 20 |
| Cost of canal according to second plan, with breakwaters on grillage base, . . . | $5,167,428 80 |

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It will be seen in the table of estimates that the computed cost of the locks is $1,857,677.54. Three items of which are thus stated :—

| | |
|---|---|
| Concrete for foundations side walls and coffer-dams, . . . . . | $476,205 12 |
| Cut stone masonry for invert, recess, and sides of locks, in hydraulic cement, . . . | 645,123 00 |
| Six wrought-iron gates or caissons with geering, | 300,000 00 |
| Making a total for these three items, of . | $1,421,328 12 |

The U. S. Commissioners, in their report to the Committee, state that their determination not to introduce into the report details belonging to the constructing engineer, proceeded from a want of time and not of interest in the work, and that they should always be ready to act as consulting engineers. Acting upon this suggestion, the report of Mr. Baldwin and a reduced map of the topographical survey by Mr. Chase, was transmitted to General Totten for the consideration of the U. S. Commissioners. The report was returned with a letter from General Totten,[1] expressing his regret that his public duties demanded his whole attention, and that the Secretary of War, upon application made to him, had, in view of the pressure of business in that department of the government, instructed him to notify the Committee that he could not further perform the duty of consulting engineer to the undertaking. A personal application by a member of the Committee, subsequently made, was answered in the same spirit, and the Committee have been compelled to yield their wishes in this regard to the more imperious demands of the public service.

The Committee entertain a belief that a mode of constructing the locks less expensive than the one assigned by the engineer, might be adopted, having due reference to the strength of the proposed structure, and to public convenience, and are of opinion that an examination of the subject by the U. S. Commissioners would have resulted in the suggestion of a plan reducing the general estimate of the whole work constructed upon the

[1] Appendix, VII.

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first model to at least $7,000,000, and on the second model to less than $5,000,000, upon the least expensive route.

In making these reflections the Committee intend no impeachment of the experience, the judgment, or the fidelity of Mr. Baldwin. On the contrary, they are entirely satisfied with the zeal and attention which he brought to the undertaking, and they consider his report as invaluable for the information which it imparts touching every branch of the undertaking, and as exhausting to a very great extent the subjects upon which it treats. But in selecting the models for the locks and breakwaters, the judgment of the Committee inclines to the opinion that much consideration is given to the strength and splendor of the work, and that a desire to project plans that the present state of engineering science sanctioned and his own judgment fully approved, has to some extent overlaid those considerations of economy which necessarily enter largely into the question of the utility of the undertaking. While therefore the models selected may be well said to approach the highest standard for such structures, and their adoption to reflect great credit upon the judgment, talent and researches of the engineer, there can be but little doubt that the work might be substantially constructed for the sums last stated, using the materials suggested by Mr. Baldwin.

Major Perault, in his report upon the canal, made in 1825, thus speaks of the piers which would be necessary to form the harbor in Barnstable Bay :—

"With respect to the piers, I would suggest the idea to have them done in fascinage, as has been done in Dunkirk, in France. Of the practicability of such a kind of work, I can afford the following instance:

"In the year 1804, while I was at Beaufort, South Carolina, the inhabitants wanted to establish a communication between the island and the main; two attempts to do it by embankments in earth, walled with stone, under the direction of persons from the North, failed completely; the seas being there very tempestuous, I suggested to Mr. Elliot, who owns the land where the ferry was to be established, the idea of a fascine work, and I directed the beginning of the operation. The work was completed on that principle and plan, and since has resisted storms which have had but few examples of the like before."

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The engineer employed by the Committee had no experience in fascine work, and has made no estimate of the expense of these piers, under that mode of construction. The success of such structures at Beaufort, tends to show that they might be used in Barnstable Bay, and Major Perault's opinion coincides with that idea. If they could be made to resist the action of the waves in that bay, the cost of this canal and the proposed harbors will be very materially reduced from the lowest estimate before given, in addition to the saving, which it is supposed may be made in the construction of the locks upon a plan less expensive than that given in the engineer's report.

The nature and probable cost of the canal offered no objection to the undertaking. Works of a similar character have long existed, and are in successful operation. Without citing those of antiquity, or the well known structures in this country, (some of which are referred to in Mr. Merrill's report,) works of a like character are to be found in most countries where any attention is given to commerce, either foreign or domestic.

Canals of various capacities are in operation in Punjab, one of which of 265 miles long, 120 feet wide, and $8\frac{1}{2}$ feet deep.

In Hungary, the Frances Canal, from Monaster to Foldvan, uniting the Danube to the Theiss, and effecting a saving of 200 miles, is 60 miles long.

In Spain, the Aragon Canal, which extends in the direction of the Ebro from Fudela almost to Sastago, is 80 miles long, 9 feet deep, and of an average width of 69 feet.

In France, the Canal of Languedoc begins at Toulouse on the Garonne, traverses rivers and mountains, and in connection with the Canal of Cette, unites the Atlantic with the Mediterranean. Its general breadth is 60 feet, its depth $6\frac{1}{2}$ feet. It has 114 locks and sluices, and at its highest point is 600 feet above the level of the sea. The Canal of Briare unites the Loire with the Seine, and is 40 miles long. The Canal of the Centre, uniting the Saone with the upper part of the Loire, is 72 miles long. The Canal of Besancon joins the Saone and Rhone with the Rhine, and has a length of about 200 miles. The Canal of St. Quentin, 28 miles long, unites the Scheldt with the Somme.

In 1836, France had 2,280 miles of canals, and from that time



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to 1854 there had been 227,695,500 francs expended upon similar works.

Belgium has an inland navigation of 376 miles. None of the canals being less than 12 miles, and one from Brussels to Charleroy being upwards of 46 miles long.

In Canada, the Welland Canal, extending from the head of Lake Ontario to the foot of Lake Erie, overcoming the Falls of Niagara, is 28 miles long, with a feeder branch 21 miles. Its width at bottom is 35 feet, at top 71 feet, and the depth of water 10 feet. Its amount of lockage is 346 feet, which is obtained by 27 locks, from 150 to 200 feet long, and from $26\frac{1}{2}$ to 45 feet wide. The St. Lawrence canals connecting Lake Ontario with the River St. Lawrence, at Montreal, extend in all $40\frac{1}{2}$ miles, having 27 locks, and an amount of lockage of $204\frac{3}{4}$ feet. The dimensions of the locks equal that of the Welland Canal, and they contain 9 feet of water.

The Caledonian Canal, from Moray Firth through the centre of the Highlands to Lake Linnhe, is, including three lakes, 60 miles long. The artificial portion of the canal is 23 miles long, 122 feet wide at the top, 50 feet at the bottom, and from 17 to 20 feet deep. The summit level is about 80 feet above the level of the sea. This canal was made to avoid the dangers of the Pentland Firth.

The North Holland or Helder Canal, connecting the latter place with Amsterdam, a distance of 51 miles, to avoid the danger of navigating the Zuider Zee, is 125 feet wide at the water surface, 31 feet at the bottom, and 20 feet deep. The surface of this canal is below the level of the German Ocean at high water, and is protected from it by embankments faced with wicker-work. Vessels are locked down from the ocean into the canal.

The history of most commercial nations shows the large expenditures that have been made upon many of the seaports now available for commerce, and those of France may be referred to as instances involving an enormous expense.

Holland also affords an instance of an expenditure of money for the protection of material interests, perhaps unexampled. Its dykes stretching along the coast, and those which line the rivers and canals, with the requisite sluices, draw-bridges and hydraulic works, are estimated to have cost £300,000,000.

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The few instances above cited of similar undertakings are sufficient to prove that works of this kind are not untried experiments, and also that obstructions and dangers to commerce have generally been surmounted by such structures as the one proposed.

The Caledonian and Helder canals are parallel cases. Both were constructed in order to avoid a navigation dangerous to life and property, and embarrassing to commercial enterprise, and every argument that could be urged in favor of their construction may be pleaded in behalf of the one under consideration. In comparing the Caledonian Canal with the one proposed across the isthmus, it should be remembered that the latter has less than one-seventh the length, and but one-eighth the amount of lockage of the former.

The canal is designed to carry 18 feet of water, and to obtain its supply from Barnstable Bay, where the mean height of high water is 4 feet .59 above the mean sea level. It is supposed that a full supply of water might be obtained by fixing the level of water in the canal at 3 feet above the mean sea level, and calculations based upon that level, and also upon the level of 3.50 and 3 feet have been made by the engineer. But to ensure a supply of water sufficient to accommodate vessels of eighteen feet draught at all seasons of the year, it is suggested that the bottom of the canal, to the extent of eighty feet wide and two feet deep, might be dredged should circumstances require it, and the estimates have been made to include the expense of such dredging.

The most important object to which attention ought to be directed in constructing a canal, is a supply of water, on which its efficiency mainly depends, and the engineer has furnished an elaborate table upon that subject, based upon the tides observed by Mr. Mitchell from July 17 to August 17, 1860.

| | |
|---|---|
| By this table it appears that, supposing the level of the canal to be kept at four feet above the mean sea level, there would flow into the canal through the twenty-four sluices (each five feet square) in the bulkhead of the sluice-way, an amount of water equal to, cubic feet, | 896,144,620 |

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|---|---|
| With the surface of the canal at this height seven lockages could be made while one tide was above this level, allowing 26 minutes for each lockage, during which the aggregate volume of water discharged into the canal would be 234,005 feet, which multiplied by 47, the number of tides that were above the four feet level during the time, gives of cubic feet, . . . . . | 10,998,235 |
| Making the whole supply of water to the canal, in cubic feet, . . . . . | 907,142,855 |
| By a constant lockage at both ends of the canal, say one in 26 minutes, the quantity of water in cubic feet, drawn from the canal during the same time, would be . . . . . | 509,289,600 |
| Which would leave in the canal, to supply leaks, evaporation, filtration, and for use as mill-powers, (in cubic feet,) . . . . . | 397,853,255 |
| With the surface of the canal at 3.50 above mean tide, there would flow into the canal during the same time, through the sluices, in cubic feet, . . . . . | 1,373,280,556 |
| And the canal might receive from lockages in 56 tides that rose above the 3.50 level, . . | 20,476,544 |
| Making a total in cubic feet of . . . . | 1,393,757,100 |
| The loss by lockage during the same time, upon the basis assumed in the foregoing statement, would be, in cubic feet, . . . . . | 447,540,900 |
| Leaving in cubic feet, for the purposes above stated, . . . . . | 946,216,200 |
| If the surface of the canal is reduced to three feet above mean sea level, there would flow into the canal, in cubic feet, during the same time, . . . . . | 1,968,843,812 |

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| | |
|---|---|
| And the canal might receive by lockages from 59 tides that rose above the three feet level, in cubic feet, . . . . . | 30,830,214 |
| Making a total in cubic feet of . . . . | 1,999,674,026 |
| The loss by lockage during the same time, would be, in cubic feet, . . . . . | 402,495,420 |
| Which would leave as surplus, for the purposes indicated in the first statement, in cubic feet, . | 1,597,178,606 |

The surplus in the first case amounts to 78 per cent. of the total lockage; in the second, 211 per cent.; and in the third, 397 per cent.

It may be safely assumed that there will be no deficiency in the supply of water for the canal at the highest proposed level, provided the water can be stored for lockage.

The superficial area of the canal and its basins is about 8,200,000 square feet. And to supply the lockage for a single tide with the water at 4 feet standard level, that area will be drawn down more than one foot. At 3.50 level it will be reduced $\frac{9}{10}$ of a foot, and at the level of 3 feet, a little more than $\frac{8}{10}$ of a foot.

To prevent this fluctuation of the canal level, and to hold a supply for the neap tides, reservoirs will be required, to contain the necessary surplus water. For this purpose may be used—First: Buttermilk Bay, which may be united to the canal by a shallow cut, from the lower part of Monumet River. The embankment for the railroad would form a dam for retaining the water in the bay, at the level of the canal; and at the outlet of the bay another might be placed at the site of the present pier and drawbridge. Second: Back River, with its marshes and ponds, would make a reservoir of five or six millions of square feet. A dam must be erected at Back River Harbor, and the reservoir united with the canal by a cut through Salt Pond. Third: The Sagamore marsh, with an area estimated at 24,000,000 square feet. This could be isolated from the sea, and connected with the canal.

By making all the above connections, a considerable amount of fresh water would be introduced into the canal, as the area of their respective water-sheds is supposed to embrace about 29

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miles; and they would furnish for the use of the canal, making a proper allowance for evaporation and filtration, 2,657,990 cubic feet of water per day; and for thirty days, 79,739,700 cubic feet; which last amount should be added to the above comparative statements showing the amount of water remaining in the canal after thirty days' lockage.

The opportunities which the location of this canal affords for discharging any surplus water that might accumulate from the extended water-shed mentioned above, renders it unnecessary to offer any remarks upon the subject of waste wiers; and stop-gates and offlets would be of no utility in a canal of this design. The draining of tow-paths when such slight cuttings occur, presents no difficulty to the engineer; nor is it supposed, from the nature of the soil, that an application of puddle to prevent leakage, will, to any considerable extent, be required.

In collecting the statistics of the commerce and navigation passing round Cape Cod, and which it is supposed would to a greater or less extent be benefited by the proposed canal, the Committee have derived much advantage from the reports of the Board of Trade, and been greatly assisted by its secretary and by gentlemen connected with marine insurance, and with the commerce of the city of Boston. The details of shipwrecks which appear in the Report have been obtained from the "Shipping List," and from personal investigation. Those collected by the Committee are without date and last in order. The aggregate of the shipwrecks embrace a period of seventeen years, in which are contained a part of 1843 and of 1859, with the intervening time.

| | |
|---|---|
| The investigations of the Board of Trade upon the subject of coastwise commerce lead to the conclusion that the imports of Boston from the port of New Orleans amount annually to . . . . . | $25,000,000 00 |
| And from the other Southern ports, to . . | 15,000,000 00 |
| There was received in Boston from Pennsylvania in 1859, 370,827 tons of coal, 112,519 barrels of flour, and 466,238 bushels of corn. Reckoning the coal at $4 per ton, the flour | |

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|---|---|
| at $5 per barrel, and the corn at 60 cents per bushel, the aggregate value of the three articles was . . . . . | $2,325,057 80 |
| The merchandise brought to Boston from New York and all other ports in the Free States south of Boston, excluding Pennsylvania, is estimated at . . . . . | 12,000,000 00 |
| It is estimated that the city of New York receives from Massachusetts, New Hampshire, and Maine, annually, cotton fabrics amounting to . . . . . | 21,000,000 00 |
| The sales of clothing have reached in one year in the city of Boston, $12,000,000; of this it is estimated there passed round the Cape | 3,000,000 00 |
| The value of boots and shoes manufactured in Massachusetts is about $40,000,000 annually; of this amount it is supposed there passes the Cape about . . . . . | 20,000,000 00 |
| Of the woollen goods manufactured in Massachusetts, New Hampshire and Maine, the amount going round the Cape is estimated at . . . . . | $3,000,000 00 |
| The ice shipped from Boston coastwise, in 1859, was 88,486 tons, at $2 per ton, . | 176,972 00 |
| Making a total of . . . . | $101,502,029 80 |
| The number of vessels coastwise, passing round the Cape annually, is estimated at 10,000, two-thirds of which enter the port of Boston; and the average tonnage of each vessel is set down at 200 tons, the value per ton at $35. Upon this computation the value of the shipping engaged in the coasting trade around Cape Cod, is . . | $70,000,000 00 |

The Committee assume that the cost of insurance from New York to Boston, through the canal, would be the same as from New York to Providence. The present rate of insurance from New York to Boston, round the Cape, is estimated to average

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$\frac{3}{10}$ of one per cent. above the rate from New York to Providence. Taking $170,000,000 in round numbers as the value of the ships and merchandise annually passing round the Cape, and supposing 40 per cent. of the navigation to use the canal, then upon the foregoing data the amount annually saved in insurance by its construction will be $204,000.

The average time of passing round the Cape above that which would be required to go through the canal is supposed to be three days. The average cost per vessel is estimated at five dollars per day, and the boarding each crew (five persons to a vessel) two dollars and fifty cents per day, making for the three days $22.50. On this data, the aggregate sum for ten thousand vessels is $2,250,000. Assuming 45 per cent. of the navigation to use the canal, there would be saved annually $1,012,500 on this item, two-thirds of which would accrue to Boston commerce.

The number of marine disasters occuring in the vicinity of Cape Cod during the seventeen years above specified (as ascertained by the Committee) is 827, to wit: 4 steamers, 40 ships, 71 barks, 191 brigs, 492 schooners and 29 sloops. The character of the losses are classified as follows: Total, 500; partial, 327. The number of shipwrecks is probably below the truth; and the classification of the losses is justified by the evidence before the Committee. It is undoubtedly a near approximation to the truth. The average number of disasters for each year is forty-eight and a fraction. In a list of five hundred and ninety-two, wherein the date of each accident is given, it is found that the largest number in any one month occurred in December. January and November had the same number. March had the next highest, and April and September each exceeded February. The highest number in one month (December) was 95; the lowest (July) was 13. The amount of property lost was collected in one hundred and eight cases only, viz.: 7 ships, 10 barks, 27 brigs, 62 schooners and 2 sloops. The proportion of the different vessels in this list does not essentially vary from the proportion observable in the general list of losses, and the aggregate loss in the 108 cases is reported to have been $1,835,500. Assuming this list to be a

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fair average of the 500 reported as having suffered a total loss, the amount of loss for the five hundred would be within a fraction of $8,500,000, showing an average annual loss in this class of shipments of a half million of dollars. The Committee have no data by which to determine the amount of property destroyed in the class of disasters denominated partial losses. The number of cases in the seventeen years is 327. The average value of vessel and cargo in the list of 108 cases of total losses is about $17,000. Assuming the partial losses to average 25 per cent. of the total losses, the whole amount of partial losses in 327 cases would be $1,389,750, showing an average annual loss in this class of disasters of $81,750.

A glance at the table in the Appendix will show how nearly the disasters happening east and south of Cape Cod approximates to the whole number, and tend to demonstrate that, in coming to the conclusion that forty per cent. of the coastwise navigation would seek the canal, the Committee have done no more than justice to the caution of their countrymen.

In forming an opinion of the security which a canal across the isthmus would afford to this navigation, the advantages of the harbors to be constructed at each end of the canal should be taken into consideration. Back River Harbor, with the proposed improvements, will offer a safe asylum for vessels south of the Cape, and can be made at all times with the wind south and west. The contemplated breakwaters in Barnstable Bay will give a harbor of refuge sufficient for the navigation north of the Cape, and can be entered with north and south-east winds. How many of the shipwrecks incident to the coast of Massachusetts may be avoided by the construction of the proposed canal and the contemplated harbors adjoining thereto, must be matter of conjecture. The Committee, however, upon consideration of all the facts collected and bearing upon the subject, taken in connection with the security which the canal and harbors would afford, come to the conclusion that the projected works would diminish the shipwrecks one-half, and effect an annual saving in this item of $290,875.

Without entering farther into the statistics touching the pecuniary advantages resulting from the opening of a water communication between the two bays, it already appears, upon



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the data above given, that there would be annually saved to the public by the construction of this work, as follows, to wit:—

| | |
|---|---|
| In insurance, . . . . . | $91,800 00 |
| In expense of navigation, . . . . | 675,000 00 |
| In decrease of shipwrecks, . . . | 290,875 00 |
| Making a total, . . . . | $1,057,675 00 |

Another consideration of still greater importance connected with this branch of the subject remains to be stated, viz.: the loss of life attendant upon the numerous shipwrecks connected with this navigation. The difficulty attending the accurate collection of statistics in this branch of the Committee's inquiry was greater even than in that of the loss of property by shipwreck. The loss of life was reported in seventy-two cases only. In three of these all hands are reported lost, without any enumeration. In the other sixty-nine the losses are stated at 305. Assuming the crews to average five persons to a vessel, the amount of loss in the seventy-two cases is 320, which is within a fraction of nineteen annually. When it is considered that this amount of loss occurred in seventy-two out of the five hundred cases of total loss, it will be safe to estimate the loss of life in this navigation at thirty annually.

If the foregoing statistics can be relied upon as showing the expense which the perilous navigation around Cape Cod imposes upon the commerce of Boston, a necessity for the construction of this canal would seem to be apparent. The Committee have confidence in their general accuracy. Many of them are founded on the researches of the Board of Trade, and care has been taken to verify the whole by such evidence as the nature of the case admitted; taking the opinion of insurance officers and mariners for the estimates touching the rates of insurance, the expenses of navigation, and the probable use of the canal, as well as the security to commerce which that and the harbors would afford. The coastwise navigation seeking other ports have been omitted in the enumeration, of which, in 1859, there arrived,—

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| | |
|---|---|
| In Gloucester, . . . . . | 156 |
| In Salem, . . . . . | 162 |
| In Newburyport, . . . . . | 238 |
| In Portsmouth, N. H., and other ports in Mass., say, . | 400 |
| Total, . . . . . | 956 |

This omission will tend to show a desire not to overestimate the details which in their aggregate indicates the present pecuniary advantage that may be expected to accrue to the com merce of the country by the construction of the canal. Its prospective benefit may be calculated in view of the foregoing facts, and of the growth and prosperity of the city of Boston, (whose valuation has increased in sixty years from fifteen to two hundred and seventy-six millions,) together with the productive power of the States of Maine, New Hampshire, Vermont and Massachusetts, within whose limits two rivers (the Merrimac and Saco) contain a water-power sufficient to manufacture the clothing for one hundred millions of people.

The proposed canal would be essentially advantageous to the country in time of war, by affording a comparatively secure route for commerce between Boston and New York and the intervening ports. In the extent of coast from Back River Harbor to New York there are twelve harbors sufficiently important in a commercial view to call for special surveys by the general government. In this enumeration many harbors on the mainland, and those on Martha's Vineyard and Block Island, are not included. The commerce between these harbors and New York would necessarily, in time of war, receive the protection of one or two national vessels cruising between Montauk Point and Gay Head. These vessels would, at the same time, protect the direct trade between New York and Boston to the entrance of Buzzard's Bay. The dangers of the coast, arising from its numerous shoals and the frequent storms to which it is subject, affords great security from enemies' ships destitute of pilots. Its insecurity for sailing vessels has passed to a proverb, and foreign steamers in their difficulty of procuring coal, could hardly give annoyance to a commerce protected by similar vessels having access to all points of the coast, for a supply of fuel. A similar force in Boston Bay would afford

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adequate protection to the passage from the northern embouchure of the canal to Boston Harbor. These considerations, joined to the fact that on being chased by an enemy a vessel making Buzzard's Bay would effectually make Boston Harbor, adds greatly to the necessity otherwise existing for the completion of the proposed work.

The Resolution authorizing the appointment of the Committee directed them to determine upon the best route for constructing the canal. In prosecuting their labors the attention of the Committee was first directed to the valley which has so often been explored and surveyed for that purpose, and the means placed by the legislature at the disposal of the Committee have enabled them to furnish the explorations, surveys, plans and estimates for one route only. It is quite probable that the one so often selected as offering the most advantages will prove to be the best that can be found for the location of a canal. In view, however, of the necessity for breakwaters in Barnstable Bay, it may be material to say that a canal might be constructed from Buttermilk Bay through Herring Pond to enter in Barnstable Bay at a point northerly of Peaked Cliff. Upon this route more dredging would be required at the southerly end; the line of excavation would be about five miles, one of which, running through Herring Pond, (whose bottom is nearly on a level with low water in Buzzard's Bay,) would be comparatively slight. The land upon this route is more elevated than on the site surveyed. Its adoption would save the western breakwater, as the parallel shore extending to Centre Hill Point, would afford sufficient shelter in that direction, and the earth excavation would materially assist in the construction of the eastern breakwater. But for the reason above stated the Committee can present no details justifying any judgment upon the practicability or the economy of the route.

The valley of the Scusset and Monumet has been explored and surveyed with reference to the construction of a ship canal across the isthmus, six times, of which an account has been preserved. Four different plans and records of surveys are accessible to the public. The variation between the surveys are so slight, the difference in the located lines so inconsiderable, and the nature of the ground surveyed so easily to be comprehended, that the Committee believe no other general survey

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of this locality is required; and they have provided for the preservation of all the papers connected with the last survey.

It will be remembered that Mr. Hill, who made the survey in 1792, selected for the southern terminus of the canal the mouth of Monumet River; but the reason for this selection does not appear in any record of that survey now remaining in the public archives. It is possible that an examination of the bay in that locality may justify his choice. If it should be deemed advisable to take soundings at the mouth of the Monumet, and extending thence into the bay, a few days' labor would determine the preference between that point and Back River Harbor.

The peculiarities attending the operation of the two tide waves upon the coast, has in every instance suggested to the engineers the necessity of using locks for this canal. The petition of James Sullivan and others to the legislature, in 1798, stated that upon a re-examination of the old project of opening a canal from the sea on the north to the sea on the south side of Cape Cod, they were inclined to the belief that the same was practicable on principles and by means which were not formerly thought of. But what the principles that influenced the minds of the petitioners were, the Committee have failed to discover, and the papers of the late Gov. Sullivan throw no light upon the subject. The survey of Mr. Bacheller, which in 1802 was stated to be a recent one, may have had some connection with this petition; but the only information obtained concerning that transaction is in the notice cited from the Historical Collections.

If some plan could be devised to overcome the force of the currents, and thereby form a free channel for the transit of vessels through from bay to bay, there could hardly be a difference of opinion upon the propriety of constructing the proposed passage, and the question whether the currents can be controlled in any other way than by locks, deserves some consideration. This question was not particularly examined while the U. S. Commissioners were connected with the surveys and soundings, and their public engagements since that time, (as already stated,) have deprived the Committee of their judgment and advice upon this branch of the subject.

The plans suggested by all the engineers who have been

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employed in these surveys, afford strong evidence that upon the valley location, covering a distance of less than eight miles, some structures are necessary to counteract the force of the current. But the plan of placing the bottom of the canal so deep as to secure eighteen feet of water at low tide, and thus avoiding the lift to high-water level, has not perhaps been considered. It may not be unreasonable to suppose that some method of avoiding the force of the currents might be discovered without the cost and delay of using locks and gates. If a safe and convenient passage can be constructed which will allow of the transit of vessels with reasonable expedition, it is quite certain that the entire navigation would seek the channel, and that the benefit thereby to be conferred on the coastwise commerce would be double the amount shown by the foregoing statistics.

In consequence of the irregularity and inequality of the rise, and of the water in the bays, the mean difference in the height of the same is 5.79 feet at two periods during the day, which is an elevation of about nine inches to the mile. Although this inequality is continually lessening, and the water is at an equilibrium twice a day, still it is supposed that the currents produced by the fluctuation of the tides would be too strong to render a free channel of the length surveyed by the engineer practicable for navigation. A fall of three inches to the mile is not considered objectionable, and is met with in many of the canals in use. The proposed Atrata ship channel, to unite the Pacific and Atlantic oceans, whose length, including the Atrata and Truando Rivers, is one hundred and twenty-five miles, has a fall of three inches to the mile, which is calculated to give a current of two and a half miles per hour.

By increasing the length of this canal to twenty miles the supposed obstruction from currents would be overcome, and the inconvenience, expense and delays of locks, basins and breakwaters might be avoided. A canal upon this plan would require a deeper excavation than the one proposed by the engineer in order to give a depth of eighteen feet at low water. But when once completed, it would require but trifling expense for repairs, and the cost attending its navigation would be comparatively small.

A calculation of the expense of such a channel, constructed of the same width as the first plan proposed for the Sagamore

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route, may be made upon the estimate of that route, as prepared by the engineer.

Assume the channel to be three times the length of the canal, $7\frac{73528}{100000}$ miles, and the excavation will be three times $1,018,459.20, . . . . . $3,055,377 60

Add for the extra excavation of nine feet, two-thirds, . . . . . 2,036,918 40

Add three times the cost of land and buildings, $62,650, . . . . . 187,950 00

$5,280,246 00

To this estimate should be added whatever additional expense the peculiarities of the route selected would create.

If the vicinity of Plymouth be adopted for the northern embouchure of the channel, a straight line to Mattapoisett will be about twenty miles; to Sippican about eighteen miles, and to Indian Neck about sixteen. Upon either route there would be many roads to be crossed, and deep cuttings to be made. From Plymouth to the head of Buttermilk Bay is less than fourteen miles in a direct line. This route might prove too short to overcome the difficulties of the current, while its excavations would be deep, and its location would to some extent incommode the public travel. A channel, however, commencing at Plymouth, or between Plymouth and Elisha's Point, might be constructed on a route following the shore line, at a suitable distance therefrom, without interfering with the public travel to a greater extent than the canal route surveyed by the engineer, and might terminate either at Buttermilk Bay, or, following down the coast to the Scusset Valley, unite with Buzzard's Bay at the mouth of the Monumet or at Back River Harbor, adopting, from a point near Scusset Village, the identical line surveyed by the engineer. This last route would give a length of twenty miles. That terminating at the head of Buttermilk Bay will give about eighteen miles.

The surveys made under the direction of the Committee, having been confined to the route for the canal in the valley, no definite description of the land north of that line can be given; but from what is generally known of the formation of the coast, and from what is observable from an examination of

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the map, the route along the coast from Scusset to Plymouth, may be considered not very unlike the route through the valley, and no extensive cuttings upon the line need be apprehended. The Committee are without any reliable information concerning the effect of the currents upon the coast between Isaac's Point and Plymouth Harbor; the tidal observations made in Barnstable Bay not extending north of Peaked Cliff. Deep water can probably be reached at this point with as little expense as at the termination of the surveyed routes, near the mouth of the Scusset. And, while an entrance into the bay south-easterly of Monumet Point, upon the plan proposed by the engineer, might require a breakwater to protect the mouth of the channel from the drift, it does not follow that any costly work would be necessary for that object westerly of Elisha's Point. If a harbor of refuge should be deemed essential at that point to the security of the commerce in Barnstable Bay, the embouchure of the channel might be constructed, at a comparatively small expense, so as to form a harbor, without constructing a breakwater or piers for that purpose.

In offering these suggestions touching the practicability of a ship channel to avoid the inconvenience of locks and gates, the Committee must not be understood as doubting the possibility and utility of constructing a canal according to the plan, and upon the route laid out by the engineer. The advantages of a free ship channel occurred to the Committee so forcibly, that it became their duty to allude to them, and to the mode of obtaining them, in order that the comparative utility of the two modes of communication might be considered in any further action upon this question. The increase of the coastwise navigation has been so great, as well in the size as in the number of vessels employed in that service, that it is now apparent that a canal constructed upon either of the plans contemplated in 1825, would altogether fail of serving its intended purposes. With this fact demonstrated, and in view of the probable growth of the domestic trade of the country, it is important that public attention should be specially directed to the necessity of providing for a communication between the bays, that will prove sufficient to secure the safety and accommodation of the future as well as the present commerce of those waters.

And while the choice of the mode of construction is sub-

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mitted to the judgment of those who may finally be called to act upon the question, the Committee are of opinion that, in view of the dangers incident to the navigation around Cape Cod; the great loss of life and property annually occurring to the commerce of that coast; the expense attending the same, and the present and increasing importance of the interests connected with and dependant upon the navigation, a ship channel or canal should be constructed, to unite the waters of Barnstable Bay with those of Buzzard's Bay, and that the Governor of the Commonwealth, at some suitable time, should lay the subject before the legislature; and also, that he should cause the same to be presented to the Congress of the United States for consideration, in such manner, and at such time, as he may deem expedient.

GEORGE ODIORNE, } Senate,
G. M. FISK, }

TAPPAN WENTWORTH, }
AMOS A. DUNNELS, }
GEORGE FOSTER, } House,
WILLIAM NYE, JR., }
R. A. PEIRCE, }

*Committee appointed in* 1860.

November 5, 1862.

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The Committee appointed in 1861, in a preliminary Report, made to the legislature in April last, stated the reasons for uniting with the Committee of 1860, in a general Report, and in pursuance of the determination then made, they hereby express their concurrence in the foregoing Report.

G. M. FISK, } Senate,
GEO. A. SHAW, }

R. A. PEIRCE, }
ANSEL LEWIS, }
JOHN S. E. ROGERS, } House,
GEO. H. BROWN, }
SAM'L O. WHITMORE, }

*Committee appointed in* 1861.



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# APPENDIX.

## [I.]

*A Table of Shipwrecks occurring around Cape Cod from* 1843 *to* 1859.

### 1843.

Nov. 8. Schooner Splendid, ashore off Chatham.
8. Bark Mohawk, ashore off Hyannis.
8. Schooner Carlew, ashore off Nantucket.
Dec. 10. Schooner Mary Rose, put into Barnstable. Partial loss.
12. Schooner Rienzi, put into Provincetown. Partial loss.
Brig Draco, at Holmes' Hole. Partial loss.
27. Bark Kasen Lecke, on Cape Cod.
28. Sch ———, off Chatham. Total loss.

Bark Mohawk, Hyannis. Total loss.
Schooner Splendid, ashore off Hyannis.
Schooner Bolivar, Chatham. Partial loss.
Schooner Atlantic, ashore off Oysterville.
Schooner ———, ashore off Holmes' Hole.
Schooner ———, ashore off Little Round Shoal. Total loss.
Brig Melomon, ashore off West Chap.
Schooner Marion, ashore off Hyannis.
Ship ———, Vineyard Sound. Total loss.
Sloop J. G. Myers, Hyannis. Total loss.
Brig President, ashore off Chatham.
Schooner Reside, ashore off Truro.
Schooner Wave, ashore off R. Point.
Brig Ganges, ashore off Wood End.
Schooner Fort Hill, ashore off Nantucket.

### 1844.

Jan. 7. Schooner Mexico, Bar off Nantucket. Cargo lost.
7. Schooner ———, near New Bedford.
7. Schooner Martha Robinson, Holmes' Hole. Vessel lost.
21. Bark Arab, went into Provincetown.

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Jan. 18. Ship Marco, Holmes' Hole.
18. Brig Souther, Holmes' Hole. Boats lost.
19. Brig Ortho, went into Provincetown.
19. Brig Hamilton, went into Edgartown.
15. Schooner Maria, went into Edgartown. Cargo partly lost.
23. Brig ———, off Nantucket.
25. Brig Mary Kimball, off Eastham.
Brig Gazelle, at Holmes' Hole.
29. Brig Sarah Williams, at Provincetown.
Feb. 15. Brig Dove, went into Nantucket. Cargo injured.
8. Schooner Washy, at Holmes' Hole.
Schooner Richmond, at Edgartown.
17. Brig Bordeaux, ashore at Scituate.
18. Schooner Betsey, ashore at Cohasset.
19. Schooner Mary Maria, went into Nantucket. Cargo injured.
20. Brig Voltaire, went into Edgartown.
28. Brig Galew, at Nantucket.
28. Sloop Lagrange, at Nantucket. Crew saved.
Mar. 5. Schooner Eliza Leland, at Edgartown. Partial loss.
2. Schooner E. H. Herrick, at Hyannis. Partial loss.
14. Sloop Portugal, off Nantucket.
Feb. 29. Bark Pardita, at Provincetown.
May 7. Schooner Freedom, at Holmes' Hole.
19. Schooner Ballard, at Vineyard Sound.
Schooner Plough Boy, at Nantucket. Partial loss.
28. Schooner Cardinal, at Scituate. Partial loss.
June 8. Schooner Edward Franklin, at Vineyard Sound. Partial loss.
July 27. Brig Choctaw, off Cape Cod. Partial loss.
Aug. 2. Brig Camee, off Cape Cod. Struck by lightning.
20. Brig Moselle, off Vineyard Sound.
20. Brig Houlton, off Vineyard Sound.
21. Schooner Malvina, on Monument Point. Total loss.
Sept. 4. Brig ———, Edgartown. Partial loss.
Schooner ———, Vineyard Sound. Partial loss.
Schooner ———, Vineyard Sound. Partial loss.
5. Brig Lycoming, Edgartown. Partial loss.
5. Schooner Independence, Cape Poge. Partial loss.
29. Ship Ashland, Scituate Harbor. Partial loss.
29. Schooner Augusta Jane, Nantucket Shoals. Partial loss.
Oct. 9. Brig ———, Nausett. Total loss.
8. Schooner Champion, ashore at Barnstable. Partial loss.
7. Schooner Henry, ashore at Edgartown. Partial loss.
14. Brig Rival, ashore at New Bedford. Partial loss.
Nov. 5. Schooner Thames, ashore at Nantucket Bar. Total loss.
12. Brig Osceola, ashore at Highlands. Total loss.
24. Sloop Charles, ashore at Nantucket Bar. Total loss.
26. Brig Espelletta, ashore at Vineyard Sound. Partial loss.
29. Schooner Harriett, off Nantucket. Total loss.

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Dec. 1. Schooner Pelow, ashore at Edgartown. Partial loss.
8. Brig Osmanli, put into Provincetown. Partial loss.
8. Schooner Nonpareil, Race Point. Total loss.
8. Schooner Oreole, ashore at Holmes' Hole. Partial loss.
8. Schooner Pallas, ashore at Holmes' Hole. Partial loss.
8. Schooner New England, ashore at Holmes' Hole. Partial loss.
8. Schooner Oliver Cromwell, ashore at Holmes' Hole. Partial loss.
8. Schooner Superior, ashore at Holmes' Hole. Partial loss.
8. Sloop Zenas, ashore at Holmes' Hole. Partial loss.
8. Schooner Exile, ashore at Scituate. Total loss.
9. Schooner Stranger, put into Provincetown. Partial loss.
11. Brig William Penn, put into Provincetown. Partial loss.
11. Schooner Wind, put into Provincetown. Partial loss.
11. Schooner Roscoe, put into Provincetown. Partial loss.
19. Schooner N. L. McCready, off Cape Cod. Partial loss.
19. Schooner Cinderilla, off Cape Cod. Partial loss.
19. Schooner Litchfield, ashore at Nantucket. Total loss.
19. Schooner Marblehead, ashore off Cape Cod. Partial loss.
20. Schooner Dove, ashore at Chatham. Partial loss.
27. Schooner Waterloo, on Nantucket Bar. Partial loss.

Schooner Palow, ashore at Horse Shoe.
Schooner ———, Vineyard Sound. Total loss.
Schooner ———, Vineyard Sound. Total loss.
Schooner ———, Vineyard Sound. Total loss.
Brig Cumberland, Truro. Total loss.
Brig Frances and Louisa, Nauset. Total loss.
Schooner Carribean, South Point. Total loss.
Schooner Plover, South Point. Total loss.
Schooner Lexington, South Point. Total loss.
Schooner Diskau, South Point. Total loss.
Schooner Aid, South Point. Total loss.
Sloop Hannah and Maria, Nauset. Total loss.

## 1845.

Jan. 1. Schooner Francis, Cape Cod. Partial loss.
6. Brig Cremanco, Nantucket Harbor. Partial loss.
14. Schooner Maria, at Nauset Light. Total loss.
14. Schooner Mary, ashore off Chatham Light. Partial loss.
14. Brig Marine, ashore at Scituate Light. Total loss.
15. Brig North America, put into Holmes' Hole. Partial loss.
Feb. 4. Bark Elk, off Cape Cod. Partial loss.
4. Schooner ———, ashore at Plymouth. Total loss.
4. Schooner Saluda, ashore on Cape Cod. Total loss.
4. Schooner Mariner, ashore at Holmes' Hole. Partial loss.
4. Schooner Julia Ann, ashore at Holmes' Hole. Partial loss.
4. Schooner Marietta, at Hyannis Port. Total loss.

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Feb. 4. Schooner Texas, at Hyannis Port. Total loss.
4. Schooner Lucinda Snow, at Hyannis Port. Partial loss.
4. Schooner Excel, at Hyannis Port. Partial loss.
4. Schooner Elizabeth, at Hyannis Port. Partial loss.
4. Brig Lowden, ashore at Quicks' Hole. Total loss.
4. Schooner Jaspar, at Minot's Ledge. Partial loss.
Mar. 15. Bark Ida, on Pollock's Rip. Partial loss.
18. Schooner Index, ashore on Cape Cod. Partial loss.
18. Schooner Splendid, ashore on Cape Cod. Total loss.
20. Schooner Jasper, ashore on Cape Cod. Total loss.
22. Schooner Desin, off Nantucket. Partial loss.
April 8. Brig Brittania, on Nantucket Bar. Partial loss.
8. Schooner Mary and Hannah, on Cape Cod. Partial loss.
May 8. Schooner Providence, ashore at Edgartown. Partial loss.
8. Sloop Fame, in Vineyard Sound. Total loss.
17. Brig Freighter, ashore on Cape Cod. Total loss.
8. Schooner Hydaspe, off Chatham. Partial loss.
17. Brig William, ashore on Cape Cod. Partial loss.
17. Schooner ———, ashore on Cape Cod. Total loss.
17. ——— Philadelphia, ashore at Holmes' Hole. Partial loss.
17. Schooner ———, on Nantucket Shoals. Total loss.
28. Schooner Alice and Mary, ashore at Provincetown. Partial loss.
June 12. Brig Colorado, ashore at Edgartown. Partial loss.
July 18. Ship Centurion, ashore on Nantucket Shoals. Total loss.
29. Schooner Margaret, ashore on South Shoal. Total loss.
20. Bark Oberlain, ashore on Cohasset. Partial loss.
Aug. 1. Schooner Jane, ashore on Cape Cod. Total loss.
17. Brig Lincoln, ashore on Nantucket. Partial loss.
Sept. 4. Sloop Fame, put into Chatham. Partial loss.
8. Schooner Splendid, Hyannis. Partial loss.
Oct. 13. Schooner Phebe Eliza, Edgartown. Partial loss.
13. Schooner Florence, Martha's Vineyard. Partial loss.
16. Schooner Meridian, put into Nantucket. Partial loss.
16. Brig Marian, put into Nantucket. Partial loss.
Nov. 12. Schooner Yamorer, Holmes' Hole. Partial loss.
30. Schooner Diamond, off Nantucket.
Dec. 5. Brig Partolus, at Chatham.
6. Brig Meridian, off Cape Cod. Partial loss.
7. Bark Baring and Brothers, off Nantucket.
14. Schooner Banner, off Nantucket.
16. Bark Zamorer, off Plymouth. Total loss.
16. Bark Mary and Martha, ashore at Holmes' Hole.
16. Schooner Norway, ashore at Holmes' Hole.
20. Schooner Edward, Edgartown. Partial loss.
23. Schooner Hope and Susan, Nantucket.
28. Brig Midas, Holmes' Hole.
30. Brig Grand Turk, off Cape Cod. Partial loss.

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Schooner Rappahannock, ashore at Nauset.
Schooner Albatross, ashore at Edgartown.
Schooner Sophronia, ashore at Tuckernuck.
Schooner Ida, on Pollock's Rip.
Schooner W. Hawes, Yarmouth. Total loss.
Schooner Waterloo, ashore at Nantucket.
Schooner Maria Hill, Monomoy Point. Total loss.

## 1846.

Jan. —. Schooner Sophia, near Nantucket.
Feb. 14. Schooner Mail, ashore at Marshfield Beach.
15. Schooner Eagle, South Dennis. Partial loss.
Brig Ann Reynolds, put into Edgartown. Partial loss.
Mar. 16. Brig Acton, Holmes' Hole. Partial loss.
15. Bark Earl, ashore at Nantucket.
20. Schooner St. Thomas, off Vineyard Sound, Partial loss.
April 1. Brig William Pitt, on fire, put into Chatham.
21. Schooner Arcot, ashore on Cape Cod.
21. Schooner Henry, ashore near Plymouth.
May 2. Steamer Cambria, ashore at Truro.
Feb. 15. Schooner Orleans, Moors' Hole.
May 10. Schooner Waldo, near Martha's Vineyard. Total loss.
16. Schooner Leander, off Nantucket. Partial loss.
June 19. Schooner Samuel, near Chatham. Total loss.
July 1. Ship R. G. Shaw, off Nantucket. Partial loss.
17. Schooner Augusta, ashore off Nantucket.
Schooner Nimrod, put into Hyannis.
Sept. 15. Brig William, ashore on Nantucket Point. Total loss.
Oct. 1. Bark Hamilton, Truro Beach. Partial loss.
13. Schooner President Jackson, Plymouth. Partial loss.
17. Brig Sutleg, in Vineyard Sound. Total loss.
Nov. 12. Schooner Comet, on Cape Cod. Partial loss.
Bark Panchitta, in Vineyard Sound. Partial loss.
21. Brig Old Colony, off Nantucket. Total loss.
21. Schooner Susan Jane, on Nantucket Bar. Total loss.
21. Schooner ———, on Nantucket Bar. Total loss.
23. Schooner Fly, on Nantucket Beach. Total loss.
23. Bark Gen. Greene, ashore at Holmes' Hole. Partial loss.
23. Brig Sweed, ashore at Holmes' Hole. Partial loss.
23. Brig Nauvoo, ashore at Holmes' Hole. Partial loss.
23. Brig Wanderer, ashore at Holmes' Hole. Partial loss.
23. Schooner Crescent, ashore at Holmes' Hole. Partial loss.
23. Schooner Caroline, ashore at Holmes' Hole. Partial loss.
23. Schooner Sally, ashore at Harwich. Partial loss.
23. Schooner Album, ashore at Chatham. Partial loss.
23. Schooner Planet, ashore at Chatham. Partial loss.
27. Bark Lagrange, ashore at Truro. Partial loss.

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Nov. 27. Brig America, ashore at Cohasset. Partial loss.
27. Brig Joseph Balch, ashore at Hyannis. Partial loss.
27. Brig Science, ashore off Provincetown. Partial loss.
27. Schooner Boston Packet, ashore at Truro. Total loss.
27. Schooner Avenel, ashore at Truro. Partial loss.
27. Schooner Edward, ashore at Truro. Partial loss.
27. Schooner Elizabeth, off Nantucket. Total loss.
Dec. 12. Schooner Narragansett, ashore on Cape Cod. Total loss.
14. Schooner Croton, at Hyannis. Partial loss.
18. Brig Melazzo, near Cohasset. Total loss.
17. Bark Rosabella, ashore on Cape Cod. Total loss.
17. Bark Lagrange, ashore on Cape Cod. Total loss.

Brig St. Thomas, Nauset. Total loss.
Brig Arcot, ashore on Nauset Beach.
Schooner Rival, ashore at Tarpaulin Cove.
Schooner Charles Henry, on Great Round Shoal. Total loss.
Brig Lincoln, on South Beach. Total loss.

## 1847.

Jan. 11. Ship ———, ashore off Cohasset.
7. Schooner Aurora, ashore off Falmouth.
Mar. 21. Bark Cactus, off Truro. Total loss.
23. Brig Baltic, ashore at South Wellfleet.
27. Schooner Sylvina, ashore off Nantucket.
April —. Sloop Harriet, off Cohasset Rocks. Partial loss.
May —. Schooner Gen. Lafayette, off Truro. Partial loss.
June 11. Sloop Emerald, ashore off Barnstable.
July 17. Schooner Hope and Susan, ashore off Mattapoisett.
Aug. 5. Sloop Fame, ashore at Noman's Island.
5. Brig Fame, ashore at Holmes' Hole.
Sept. 4. Brig Oreco, Vineyard Sound. Total loss.
10. Schooner Rambler, ashore off Nantucket.
20. Schooner Dispatch, ashore off Nantucket.
26. Brig Gen. Tyler, ashore off Nantucket.
25. Schooner Surplus, Hull. Total loss.
Oct. 15. Brig N. F. Frothingham, near Wellfleet. Total loss.
Nov. 6. Schooner Cordova, off Chatham. Partial loss.
9. Schooner Caravan, off New Bedford. Partial loss.
5. Schooner Commerce, off Chatham. Total loss.
28. Schooner Nancy, off Nantucket. Total loss.
29. Schooner May, off Falmouth. Total loss.
Dec. 11. Ship Mary Frances, put into Nantucket.
16. Packet ship Louis Phillipe, off Nantucket. Total loss.
19. Ship Alabama, ashore at Cohasset.
18. Schooner Malvina, at Cohasset. Total loss.
17. ——— Caroline, off Nantucket.

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Dec. —. Schooner Richard, put into Fire Island Inlet.
28. Schooner Extio, put into Provincetown. Partial loss.
28. Schooner Wolcott, off Nantucket. Partial loss.

Brig Orissa, Chatham, South Point. Total loss.
Schooner Harvard, Nauset Beach. Total loss.
Schooner Turk, ashore at Bass River.
Sloop Avon, ashore at Bass River.
Schooner Sun, ashore at Bass River.
Schooner Teazer, Cape Poge. Partial loss.

## 1848.

Jan. 8. Schooner Lion, Vineyard Sound. Total loss.
Brig John Clifford, ashore off Eastham.
15. Bark Natchez, ashore at Marshfield. Total loss.
31. Ship Concordia, ashore near Scituate.
Feb. 11. Bark Delaware, put into Holmes' Hole.
13. Schooner Gen. Foster, off Nantucket. Partial loss.
22. Schooner Potomac, ashore at Holmes' Hole.
16. Schooner Gil Blas, on Cape Cod. Partial loss.
Mar. 9. Bark Frances Bun, off Marshfield.
4. Schooner Page, ashore at Falmouth.
24. Brig Fame, ashore at Vineyard Sound.
30. ——— Golconda, off Nantucket. Partial loss.
April 17. Ship Osceola, off Nantucket.
May 19. Bark Mary Whitney, off Nantucket.
25. Schooner George and William, off Cape Cod.
31. Schooner A. Marshall, off Nantucket.
June 18. Schooner George and Alfred, at West Harwich. Total loss.
19. Schooner E. L. Hartshorn, off Nantucket.
27. Schooner Yankee, near Eastham.
28. Schooner A. C. Baker, near Eastham.
28. Schooner Emeline, near Eastham. Total loss.
Aug. 10. Schooner Medium, off Nantucket. Partial loss.
21. Brig Mary Stanton, on Nantucket.
22. Schooner Splendid, Vineyard Sound. Partial loss.
Sept. 3. Schooner Abby Hammond, on Nantucket. Partial loss.
18. Ship Rough and Ready, at Mansfield. Total loss.
19. Brig Almira, Holmes' Hole. Partial loss.
Oct. 1. Brig Oceanus, at Scituate. Total loss.
Nov. 5. Brig Sirico, at Scituate. Total loss.
19. Schooner Julia Ann, Edgartown. Partial loss.
19. Schooner Exchange, Edgartown. Partial loss.
19. Schooner Mary Elizabeth, ashore at Provincetown. Partial loss.
19. Sloop Jack Downing, ashore at Provincetown. Partial loss.
19. Schooner John Simmons, ashore at Provincetown. Partial loss.
19. Schooner Hope, ashore at Provincetown. Partial loss.

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Nov. 19. Schooner Rio Grande, ashore at Provincetown. Partial loss.
19. Schooner Raritan, ashore at Provincetown. Partial loss.
19. Schooner Guess, ashore at Provincetown. Partial loss.
19. Schooner ———, ashore at Provincetown. Partial loss.
19. Schooner ———, ashore at Provincetown. Partial loss.
19. Sloop Acton, ashore at Provincetown. Partial loss.
19. Sloop J. Sawyer, ashore at Provincetown. Partial loss.
19. Schooner William Henry, ashore at Plymouth. Partial loss.
20. Ship Clara, ashore on Truro Beach. Total loss.
20. Brig Adna, ashore off Provincetown. Partial loss.
20. Bark Como, ashore at Herring Cove. Partial loss.
20. Schooner Brutus, ashore off Yarmouth.
20. Schooner Atlas, ashore off Yarmouth. Partial loss.
20. Schooner Sultana, ashore off Cape Cod. Partial loss.
Dec. 21. Schooner Van Buren, ashore on Nauset Beach. Total loss.
27. Schooner A. P. Fielding, ashore off Provincetown. Total loss.

Schooner Lion, ashore at Channel.
Schooner Richard, Boston Bay. Total loss.
Bark Kate Kearney, Nauset Beach. Total loss.
Brig E. O. Holt, South Point. Partial loss.
Brig Isabel, South Point. Total loss.
Schooner Margaret Ann, South Point. Total loss.
Schooner Cyrus Chamberlin, Nauset. Total loss.
Sloop Rising Sun, Cape Cod. Total loss.
Schooner Oneco, Nantucket. Total loss.
Schooner Oregon, Hedge Fence. Partial loss.

## 1849.

Jan. 2. Brig Spartan, on Cuttyhunk. Total loss.
2. Brig William S. Dugan, in Vineyard Sound. Partial loss.
2. Ship Antwerp, in Vineyard Sound. Partial loss.
2. Schooner Wyoming, on Nantucket. Total loss.
9. Brig Ella, at Holmes' Hole. Partial loss.
12. Schooner Abbot Lawrence, at Holmes' Hole. Partial loss.
20. Schooner Sharon, at Woods' End. Partial loss.
13. Schooner Susan Benjamin, ashore at Orleans. Total loss.
13. Schooner Tioga, ashore off Cape Cod. Total loss.
13. Schooner John J. Eaton, ashore off Chatham. Partial loss.
Feb. 9. Bark Kate Kearney, on Chatham Bar. Total loss.
9. Brig Porto Rico, on Chatham Bar. Partial loss.
17. Schooner Matilda, off Nantucket Shoals. Total loss.
18. Ship Jenny Lind, at Cohasset. Total loss.
18. Bark Oscar, at Scituate. Total loss.
Mar. 1. Ship Franklin, at Wellfleet. Total loss.
26. Brig Sea Bird, at Marshfield. Partial loss.



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Mar. 28. Brig Canton, off Plymouth. Partial loss.
28. Schooner Lamartine, off Cape Cod. Total loss.
April 5. Ship Colchis, off Nantucket. Partial loss.
14. Brig David Pratt, on Nassau Beach. Partial loss.
May 31. Ship London, on Nauset Beach. Total loss.
Oct. 7. Brig St. John, ashore at Cohasset (99 lives lost.) Total loss.
7. Schooner Eleanor Jane, ashore at Duxbury. Partial loss.
13. Brig Lelolla, ashore off Nantucket. Total loss.
24. Schooner Amazon, ashore off Nantucket. Total loss.
Nov. 5. Bark Cornwallis, ashore off Nantucket. Partial loss.
Dec. 3. Schooner Sarah Hamilton, off Nauset. Total loss.
19. Schooner Minnesota, off Nauset. Total loss.

Brig Dracut, Nauset. Total loss.
Brig Warner, Nauset. Total loss.
Schooner ———, Monomoy Point. Total loss.
Schooner Abbot Lawrence, Tuckernuck. Total loss.
Ship Cactus, Tuckernuck. Total loss.
Schooner Danube, ashore at Monomoy.
Schooner Emeline, ashore at L'Hommedieu.
Schooner Gold Hunter, South Point. Total loss.
Schooner ———, Cuttyhunk. Partial loss.
Schooner Dolphin, Cape Poge. Partial loss.

## 1850.

Feb. 4. Schooner Augusta, on Monomoy Point. Partial loss.
Mar. 1. Schooner Eleanor, off Hyannis. Total loss.
12. Schooner Franklin, on Nantucket Shoals. Total loss.
13. Schooner Covenant, Herring Cove. Total loss.
15. Schooner Athalia, near Highland Light. Total loss.
21. Schooner Hattie Maria, on Nantucket. Total loss.
21. Schooner ———. Total loss.
April 2. Brig Ellen Maria, ashore at Martha's Vineyard. Total loss.
5. Brig L. Essal, on Nantucket Beach. Partial loss.
5. Brig Hayward, ashore on Cape Cod. Total loss.
May 1. Sloop Pilot, ashore on Cape Cod. Total loss.
June 7. Schooner Convoy, ashore off Chatham. Total loss.
14. Schooner Myrtle, ashore on Nantucket. Partial loss.
July 19. Schooner Philosopher, ashore on Nantucket. Total loss.
27. Schooner Peerless, Holmes' Hole. Total loss.
Aug. 25. Brig Velocity, ashore at Truro. Partial loss.
Sept. 8. Schooner Marinah N. Bryant, on Nantucket. Partial loss.
8. Brig Mary Perkins, on Tuckernuck. Partial loss.
8. Schooner Benj. Brown, on Monomoy Point. Partial loss.
8. Schooner D. T. Willet, on Monomoy Point. Partial loss.
Oct. 26. Schooner Magdalia, at West Harwich. Total loss.
26. Schooner ———, at West Harwich. Partial loss.

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Oct. 31. Schooner ———, on Nantucket Shoals. Partial loss.
31. Schooner ———, off Chatham. Total loss.
Nov. 17. Bark ———, off Nantucket. Total loss.
17. Schooner Homer, off Nantucket. Total loss.
17. Schooner Eliza Hupper, off Nantucket. Total loss.
Dec. 9. Ship Jacob Perkins, on Smith's Island. Total loss.

Bark Vesta, on Gull Ledge. Total loss.
Brig ———, at Wellfleet. Total loss.
Brig ———, at Wellfleet. Total loss.
Brig ———, ashore at Provincetown.
Schooner Emeline, Montague. Total loss.
Brig Victory, near Provincetown. Total loss.
Brig Eagle, near Provincetown. Total loss.
Schooner Balance, L'Hommedieu. Total loss.
Schooner Dove, Wellfleet. Total loss.
Schooner Palo Alto, Chatham. Total loss.
Schooner Seraph, ashore at Chatham.
Schooner Juno, Hyannis. Total loss.
Schooner Concert, Cape Poge. Total loss.
Schooner Ann, Wellfleet. Total loss.
Sloop Triumph, Nantucket. Total loss.
Bark Oregon, Nauset Beach. Total loss
Brig California, Nauset Beach. Total loss.
Brig Mount Vernon, Wellfleet. Total loss.
Brig Logan, Wellfleet. Total loss.
Schooner Flash, South Point. Total loss.
Schooner George Savary, Wellfleet. Total loss.
Schooner Golden Rule, Wellfleet. Total loss.
Schooner Hannah Gove, Wellfleet. Total loss.

## 1851.

Feb. 11. Brig Logan, ashore off Chatham. Partial loss.
April 16. Schooner Fredonia, ashore at Plymouth. Total loss.
16. Brig Esther, ashore at Truro. Partial loss.
16. Ship Columbus, ashore at Barnstable. Total loss.
16. Brig Water Witch, ashore at Cape Cod. Total loss.
16. Schooner Eagle, ashore at Truro. Total loss.
16. Schooner ———, ashore at Truro. Total loss.
16. Brig Elizabeth, ashore at Marshfield. Total loss.
16. Brig Wellamo, ashore at Scituate. Total loss.
16. Brig Paragon, ashore at Monomoy Point. Partial loss.
16. Schooner Uncas, ashore off Nantucket. Total loss.
May 13. Schooner Post Boy, ashore off Chatham. Total loss.
June 12. Brig Isaac Carver, ashore off Nantucket. Partial loss.
Aug. 27. Brig Venus, ashore in Vineyard Sound. Partial loss.
27. Schooner Augustus, ashore at Edgartown. Partial loss.

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Aug. 27. Schooner Union, ashore at Holmes' Hole. Total loss.
27. Schooner Orator, ashore at Holmes' Hole. Partial loss.
Sept. 21. Bark Ulster, ashore at Cohasset. Total loss.
21. Brig Partridge, ashore at Scituate. Total loss.
21. Schooner Franklin, ashore at Monomoy Point. Total loss.
Oct. 27. Ship John M. Mayo, put into Chatham. Partial loss.
Nov. 20. Brig Alphonzo, ashore at Edgartown. Partial loss.
16. Schooner Wm. Henry, ashore in Vineyard Sound. Partial loss.
30. Schooner Sanop, ashore at Cape Poge. Partial loss.
30. Brig Porto Rico, ashore at Cape Poge. Partial loss.
30. Brig Creole, ashore at Edgartown. Partial loss.
Dec. 1. Brig Lucy Ellen, ashore at Nantucket. Total loss.
1. Schooner Mary George, ashore in Vineyard Sound. Partial loss.
1. Schooner Vicana, ashore in Vineyard Sound. Partial loss.
1. Schooner Charles Alstrum, ashore at Truro. Partial loss.
1. Brig Eliza, ashore at Wellfleet. Partial loss.
1. Brig ———, ashore at Nantucket. Total loss.
11. Schooner Admiral, ashore at Wellfleet. Partial loss.
17. Ship British Queen, ashore at Martha's Vineyard. Total loss.
17. Schooner Wellington, ashore on Nantucket. Total loss.
19. Schooner Lightfoot, ashore off Chatham. Partial loss.

Schooner ———, Wellfleet. Total loss.
Brig Token, Nauset. Total loss.
Brig ———, Nauset. Total loss.
Brig Jane, Chatham South Point. Total loss.
Brig Huron, Cape Cod. Total loss.
Schooner Franklin, Nauset. Total loss.

## 1852.

Jan. 6. Schooner Caroline, ashore at Barnstable. Total loss.
11. Brig Macon, ashore off Nantucket. Partial loss.
17. Schooner Calista, ashore on Cape Cod. Total loss.
19. Bark Cuba, ashore off Provincetown. Partial loss.
19. Schooner Daniel Porter, ashore off Chatham. Partial loss.
23. Schooner J. A. Paine, ashore near Chatham. Total loss.
23. Schooner North Star, ashore near Chatham. Total loss.
Feb. 11. Ship Shanunga, ashore at Nantucket. Partial loss.
17. Brig Sunny Eye, ashore in Vineyard Sound. Total loss.
April 6. Brig Maria, ashore on Cohasset Rocks. Total loss.
6. Brig Colomo, ashore on Cape Cod. Total loss.
6. Brig ———, ashore off Provincetown. Total loss.
9. Schooner Louisa, ashore on Tuckernuck. Total loss.
9. Schooner Wm. P. Dolliver, ashore on Cape Cod. Partial loss.
13. Bark Gay Head, ashore at Duxbury. Total loss.
13. Ship Inee, ashore on Cape Cod. Partial loss.
13. Schooner Italian, ashore on Cape Cod. Partial loss.

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April 13. Bark Queen, ashore on Cape Cod. Total loss.
19. Brig Romp, ashore on Chatham Beach. Total loss.
19. Bark Jane Duffer, ashore on Chatham Beach. Total loss.
19. Schooner Sarah, ashore on Monomoy Point. Total loss.
19. Brig Ariel, ashore on Cape Cod. Total loss.
19. Brig Margaret, ashore on Nauset Beach. Partial loss.
19. Brig ———, ashore on Cape Cod. Total loss.
21. Brig Marcus, ashore on Scituate Beach. Total loss.
21. Schooner Chalcedony, ashore at Marshfield. Total loss.
May 17. Schooner L. S. Pond, ashore at Gay Head. Partial loss.
17. Schooner Pharos, ashore at Gay Head. Partial loss.
17. Schooner Mary Chilton, ashore on Cuttyhunk. Total loss.
June 9. Brig A. Dunbar, ashore on Cuttyhunk. Total loss.
9. Schooner Betsey, ashore on Chatham Bar. Total loss.
Oct. 20. Schooner Phenix, ashore near Sandwich.
19. Schooner Mary Elizabeth, ashore at Holmes' Hole.
21. Brig Roscoe, ashore at Martha's Vineyard. Total loss.
Dec. 7. Bark Ovala, ashore at Vineyard Sound. Partial loss.
9. Brig Callao, off Chatham. Total loss.
14. Schooner Vandia, off Chatham. Total loss.
24. Bark Forest, off Nantucket. Total loss.

Schooner Westover, ashore on L'Hommedieu.
Schooner Charm, ashore on Point Gammon.
Schooner Susan, ashore on Catuet.
Schooner Thacher Fanton, ashore on Cape Poge.
Schooner Haven, ashore on Truro.
Brig Sallie, on Handkerchief.
Bark Cuba, on Wood End. Total loss.
Schooner J. A. Paine, ashore on South Point.
Schooner North Star, at Chatham. Total loss.
Schooner St. Pierre, South Point. Total loss.
Schooner John Tyler, South Point. Total loss.
Schooner James A. Boyd, South Point. Total loss.
Schooner Kossuth, South Point. Total loss.
Schooner James D. Paine, South Point. Total loss.
Schooner Betsey, South Point. Total loss.

## 1853.

Jan. 3. Schooner Charles Appleton, off Nantucket (crew lost). Total loss.
4. Schooner I. O. of O. F., off Nantucket. Total loss.
Mar. 1. Schooner ———, at Marshfield.
1. Schooner Sarah Lewis, in Martha's Vineyard. Total loss.
1. Schooner Narcissa, off Provincetown (2 men lost).
1. Schooner Wm. Bacon, in Vineyard Sound. Total loss.
1. Ship Forest Queen, at Scituate. Partial loss.
1. Bark Vernon, at Scituate.

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May 27. Brig Cordelia, off Cape Cod. Total loss.
June 25. Schooner Boxer, filled off Chatham.
Aug. 24. Schooner Orient, off Chatham. Total loss.
Oct. 3. Schooner Balloon, ashore off Nantucket.
7. Schooner Othello, off Chatham.
27. Brig ———, sunk off Provincetown.
Nov. 23. Schooner N. and L. Wasson, ashore off Chatham.
Dec. 23. Schooner W. W. Dyer, ashore at Holmes' Hole.
24. Schooner J. C. Calhoun, ashore in Vineyard Sound.
29. Schooner Eben Sawyer, ashore on Plymouth Beach.
30. Brig Mary Stanton, ashore at Eastham.
30. Brig Marine, ashore at Eastham. Total loss.
29. Schooner Amaranth, ashore at Duxbury Beach.
29. Schooner Yarmouth, ashore at Yarmouth.
29. Schooner Willow, ashore at Dennis.
29. Bark Ida, ashore at Provincetown. Total loss.

Brig Virginia, ashore at Chatham.
Schooner Effort, ashore at Nantucket.
Schooner Leopard, at Nauset. Total loss.
Schooner Benjamin H. Hold, on Bishop's Clerk. Total loss.
Schooner Mary A. Taylor, Chatham. Total loss.
Schooner Orcut, Chatham. Total loss.
Ship Mary Ann, South Point. Total loss.
Brig Monte Christo, Nauset. Total loss.
Schooner Ann, Nauset. Total loss.
Schooner Tioga, ashore in Boston Bay.
Schooner Lowell, Cape Cod. Total loss.
Schooner E. Bray, Cape Cod. Total loss.
Bark Appleton, Cape Cod. Total loss.
Schooner Charles and Edward, ashore at South Dennis.
Schooner Usher, Cape Cod. Total loss.
Schooner G. K. Randall, Cape Cod. Total loss.

## 1854.

Jan. —. Schooner Philadelphia, ashore off Plymouth Beach.
—. Schooner Ina, ashore off Plymouth Beach.
12. Brig Royal Southwick, ashore in Vineyard Sound. Total loss.
13. Brig Eleanor, ashore off Yarmouth.
20. Brig Velasco, ashore off Duxbury.
20. Brig Clio, ashore off Scituate.
20. Schooner Woodell, ashore off Marshfield.
20. Schooner Emerald, ashore on Cape Cod.
Feb. 6. Schooner Alfred, ashore at Wellfleet.
6. Bark Amanda, ashore at Mansfield.
6. Brig Czarina, ashore off Chatham. Total loss.
9. Schooner William, on fire at Holmes' Hole.

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Mar. 1. Schooner Russell, ashore at Plymouth. Total loss.
19. Schooner Gold Hunter, ashore at Hyannis. Total loss.
April 10. Schooner Elizabeth, ashore at Cape Cod.
May 2. Schooner Maize, ashore at Chatham.
2. Schooner Forrester, ashore at Wellfleet. Total loss.
Aug. 18. Schooner New England, ashore at Nantucket.
Oct. 24. Brig Oneco, ashore off Nantucket. Partial loss.
Nov. 3. Schooner Signal, ashore on Chatham Bar. Partial loss.
Dec. 3. Brig T. P. Perkins, ashore off Scituate. Partial loss.
3. Brig Whittaker, ashore at Marshfield. Partial loss.
3. Schooner Boston, ashore at Marshfield. Total loss.
3. Brig Lafayette, ashore on Scituate Beach. Total loss.
3. Schooner Two Brothers, ashore at Chatham. Total loss.
20. Brig Samuel Campbell, ashore at Scituate. Total loss.

Schooner Avenue, Wellfleet. Total loss.
Bark Henry Burk, ashore at Cape Cod.
Brig Boston, ashore at Cape Cod.
Brig W. M. Rogers, ashore at Cape Cod.
Schooner Telegraph, Vineyard Sound. Total loss.
Schooner Sarah, ashore at Point Rip.
Schooner Willow, ashore at Edgartown.
Schooner Wasp, ashore at Race Point. Total loss.

## 1855.

Jan. 17. Brig Maritimay, ashore on Monomoy Point. Total loss.
Feb. 18. Brig Shackford, ashore on Cape Cod. Partial loss.
Mar. 10. Ship W. A. Cooper, ashore at Scituate. Partial loss.
10. Schooner A. Damon, ashore at Scituate. Total loss.
10. Schooner ———, ashore at Plymouth. Total loss.
10. Brig Motto, ashore on Cape Cod. Total loss.
10. Bark California, ashore on Monomoy Point. Total loss.
10. Schooner Smith Tuttle, ashore at Plymouth. Partial loss.
10. Schooner Stewart Campbell, ashore at Marshfield. Partial loss.
10. Schooner James Taylor, ashore at Holmes' Hole. Partial loss.
10. Schooner E. H. Adams, ashore at Holmes' Hole. Partial loss.
10. Sloop Conveyance, ashore at Holmes' Hole. Partial loss.
10. Ship Hudson, ashore at Brewster. Total loss.
10. Brig Civilian, ashore on Cape Cod. Total loss.
10. Bark Edisto, ashore on Orleans Beach. Total loss.
10. Bark Murrillo, ashore on Nauset. Partial loss.
10. Schooner Hutoka, ashore on Race Point. Total loss.
10. Schooner J. E. Rowley, ashore at Dennis. Partial loss.
10. Schooner Morning Star, ashore at Barnstable. Total loss.
10. Schooner Pawtucket, ashore at Barnstable. Partial loss.
10. Schooner Yarmouth, ashore at Barnstable. Partial loss.
April 10. Brig Boston, ashore on Nantucket. Total loss.

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May 20. Schooner Charles, ashore at Barnstable. Total loss.
Aug. 9. Brig John Guttenburg, ashore in Vineyard Sound. Partial loss.
25. Brig St. George, ashore on Cuttyhunk. Total loss.
Sept. 25. Schooner Cordelia, ashore off Nantucket.
—. Schooner William, ashore off Scituate.
Oct. 11. Sloop New London, ashore on Cape Cod.
26. Schooner ———, ashore off Nantucket. Total loss.
Dec. 11. Schooner Horace Nichols, ashore in Vineyard Sound. Total loss.
17. Ship Ontario, ashore off Nantucket. Total loss.

Schooner Linaton, ashore at L'Hommedieu.
Schooner Sarah Ann, ashore at Chatham.
Brig Aurora, ashore at Chatham.
Schooner Speed, Naushon. Total loss.
Brig Amos Lawrence, Chatham. Total loss.
Ship Timour, Nantucket. Total loss.
Schooner Philadelphia, Chatham. Total loss.
Brig Mary Taylor, South Point. Total loss.
Schooner Two Brothers, Nauset. Total loss.
Schooner Frederick, South Point. Total loss.
Bark Edisto, Nauset. Total loss.
Schooner Sarah Ann, Nauset. Total loss.
Brig Emily, Hedge Fence. Partial loss.
Brig Excellent, Tarpaulin Cove. Partial loss.
Schooner Monitor, ashore at Woods' Hole.
Brig Venus, ashore at Holmes' Hole.
Brig Helen Mar, ashore at Holmes' Hole.
Schooner Mecklenburg, ashore at Holmes' Hole.
Brig Cosmopolite, Skiffs Island Reef. Partial loss.
Schooner R. B. Pitts, ashore at Tarpaulin Cove.
Schooner Jane Pindle, ashore at Tarpaulin Cove.
Ship Timour, G. Rip. S. E. from Nantucket.
Ship Adams, Nantucket Shoal. Partial loss.
Schooner Canary, ashore at Tarpaulin Cove. Partial loss.

## 1856.

Jan. 6. Schooner George Savery, ashore at Wellfleet.
13. Bark Mary, off Nantucket. Partial loss.
Feb. 11. Schooner Mary C. Ames, ashore off Nantucket. Total loss.
12. Schooner Cyclone, ashore off Nantucket.
Mar. 15. Brig Venus, ashore off Nantucket.
April 28. Schooner James and Lucy, ashore off Harwich.
May 9. Schooner David Parker, ashore off Sandwich.
Aug. —. Schooner M. S. Hall, ashore off Cohasset.
—. Schooner ———, ashore off Cohasset.
Sept. 18. Schooner Julia Ann Staples, ashore off Chatham.
Oct. 6. Schooner Chalcedony, ashore off Nantucket. Total loss.

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Oct. 25. Bark John Swazey, ashore off Nantucket.
Nov. 10. Schooner Thacher Taylor, ashore off Dennis.
Dec. 5. Schooner Fair Trader, ashore off Chatham.
10. Brig Vernon, ashore at Holmes' Hole.
Oct. 24. Schooner Splendid, ashore on Tuckernuck. Total loss.
Nov. 2. ——— Charles S. Simmons, ashore on Bishop and Clerk's Ledge. Total loss.
29. Bark Solomon Piper, ashore on Chatham Bar. Total loss.
Dec. 2. Schooner Copier, ashore on Monomoy Point. Total loss.
21. Bark Jenny Lind, ashore on Race Point. Total loss.
—. Schooner Charles B. Prindle, ashore on Brewster Flats. Total loss.
—. Schooner Belcher, ashore off Provincetown. Total loss.

Brig Empire, ashore at Cape Poge.
Brig P. M. Tinker, ashore at Chatham.
Schooner Isaac Rich, ashore at Point Gammon.
Bark Canto, ashore at Nauset.
Schooner Charles Smith, ashore at Bishop and Clerk's.
Schooner Magnolia, on Cape Cod. Total loss.
Schooner Daniel Webster, ashore at Chatham.
Bark John Gilpin, Billingsgate Point. Total loss.
Bark San Jacinto, Chatham. Total loss.
Schooner Jerusha Parker, ashore at Woods' Hole.
Bark Warren Hallet, Holmes' Hole. Total loss.
Bark Tammany, ashore at Holmes' Hole.
Schooner Ariadne, ashore at Holmes' Hole.
Schooner ———, ashore at Holmes' Hole. Total loss.
Schooner Silver Bell, Cape Poge. Total loss.
Brig R. H. Moulton, ashore at Holmes' Hole.
Brig Virginia, Holmes' Hole.
Brig Emma Cushing, Holmes' Hole.
Brig Blue Bell, ashore at Cape Poge.
Steamer ———, off Gay Head.
Schooner Sarah, Outer Flats.
Brig Rechabite, Monomoy Point. Partial loss.
Schooner ———, Vineyard Sound. Total loss.
Schooner Pool, ashore at South Point.

## 1857.

Jan. 18. Ship Orrissa, ashore on Nauset Beach. Total loss.
19. Bark A. E. Cochrane, ashore on Race Point. Partial loss.
19. Schooner Sarah, ashore in Herring Cove. Partial loss.
19. Schooner Augusta Parker, ashore at Provincetown. Partial loss.
19. Bark New Empire, ashore on Cohasset Rocks. Total loss.
19. Schooner Granite State, ashore off Hyannis. Partial loss.
19. Schooner Panama, ashore off Hyannis. Partial loss.
19. Schooner Cinderilla, ashore off Hyannis. Partial loss.



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Jan. 19. Schooner Geneva, ashore on Scituate Beach. Total loss.
19. Brig Judge Hadaway, ashore on Scituate Beach. Total loss.
19. Schooner Comanchet, ashore on Nantucket. Partial loss.
19. Schooner Leonard McKenzie, ashore at Wellfleet. Partial loss.
Mar. 4. Brig Ellen Maria, ashore on Nauset Beach. Total loss.
4. Schooner Bloomer, ashore on Cape Cod. Total loss.
April 1. Schooner Richard Thompson, ashore on Cape Poge. Partial loss.
19. Schooner Tiberius, ashore on Chatham Bar. Total loss.
20. Brig Caroline, ashore at Cohasset. Partial loss.
23. Schooner Julia A. Rich, ashore in Holmes' Hole. Partial loss.
25. Bark Neuces, ashore at Cohasset. Partial loss.
May 23. Schooner Baltic, ashore off Cape Cod. Partial loss.
June 1. Steamer City of New York, on Nantucket Shoals. Total loss.
2. Bark Gen. Tyler, on Nantucket Shoals. Total loss.
—. Schooner Othello, ashore on Cape Cod. Total loss.
—. Schooner Lilly Dale, ashore on Cape Cod. Partial loss.

Brig J. R. Rhoades, ashore at South Point.
Schooner Knight, ashore on Cape Cod.
Schooner Estella, ashore at Suconesset.
Schooner Orland, ashore at Wellfleet.
Brig E. P. Sweet, ashore at Wellfleet.
Bark Chester, Chatham. Total loss.
Ship California, Cohasset. Total loss.
Schooner E. L. Hammond, ashore at Chatham.
Bark Justice Story, ashore at Holmes' Hole.
Schooner Brutus, ashore at Bass River.
Schooner Florida, ashore at Bass River. Total loss.
Schooner Maria, Nantucket Shoal. Total loss.
Schooner Julia Ann, Chatham. Total loss.
Schooner Canto, Hogs' Back. Total loss.
Schooner W. N. Freeman, South Point.
Bark Brothers, South Point. Total loss.
Bark Julia Ann, Nauset. Total loss.
Bark S. Sultan, Nauset. Total loss.
Schooner John N. Roads, off Gay Head. Total loss.
Schooner Milwaukie, Great Round Shoal. Total loss.
Schooner Surprise, Cape Poge. Partial loss.
Brig Pilgrim, ashore at Norton's Shoal.
Schooner Homer, Vineyard Sound. Total loss.
Brig Susan, ashore at East Chop.
Bark ———, ashore at Vineyard Sound.
Brig Galveston, Nashawena Island. Partial loss.
Bark Richmond, ashore at Holmes' Hole.
Schooner Astrea, Holmes' Hole.
Schooner Juno, Holmes' Hole.
Schooner Albatross, Holmes' Hole.
Schooner ———, Holmes' Hole. Partial loss.

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Schooner Four Brothers, ashore at Quick's Hole.
Brig Yankee, ashore at Perque Island.
Bark John Swasey, ashore south side Nantucket.
Sloop Escort, ashore at Woods' Hole.
Brig Vernon, ashore at Cuttyhunk.

## 1858.

Feb. 2. Bark N. G. Hitchborn, ashore off Nantucket. Total loss.
16. Schooner Eben Atkins, ashore off Chatham.
Mar. 10. Steamer Phineas Sprague, Holmes' Hole. Partial loss.
—. Schooner J. and P. Chase, ashore off Nantucket.
April 13. Ship Mountain Wave, ashore off Scituate.
—. Schooner ———, ashore at Martha's Vineyard.
—. Schooner Isaac Acborn, ashore at Nantucket.
—. Schooner Roanoke, ashore at Martha's Vineyard. Total loss.
June 17. Schooner Thos. Hills, (Ellis,) ashore at Provincetown. Partial loss.
17. Schooner Oasis, ashore at Hyannis. Partial loss.
17. Schooner A. W. Eldridge, ashore at Holmes' Hole.
30. Schooner E. S. Smith, ashore at Highland Point. Partial loss.
30. Schooner Triumph, ashore at Provincetown. Partial loss.
July 3. Schooner Adrian, at Chatham.
18. Schooner Wm. A. Hammond, off Nantucket. Partial loss.
18. Schooner Richard Vaux, off Nantucket. Partial loss.
Sept. 16. Schooner Highlander, ashore on Cape Cod. Partial loss.
16. Schooner Pizzaro, ashore on Cape Cod. Partial loss.
16. Schooner Barnstable, ashore on Cape Cod. Partial loss.
16. Schooner Rebecca, ashore on Cape Cod. Partial loss.
16. Schooner Harp, ashore on Cape Cod. Partial loss.
16. Schooner Renown, ashore on Cape Cod. Partial loss.
16. Schooner Cinderilla, ashore on Cape Cod. Partial loss.
16. Schooner Vestal, ashore on Cape Cod. Partial loss.
16. Schooner Fakin, ashore on Cape Cod. Partial loss.
16. Schooner Experiment, ashore on Cape Cod. Partial loss.
16. Schooner Ann Isabel, ashore on Cape Cod. Partial loss.
16. Sloop Pilot, ashore on Cape Cod. Partial loss.
16. Sloop Sarah, ashore on Cape Cod. Partial loss.
16. Sloop Navigator, ashore on Cape Cod. Partial loss.
16. Sloop Eliza Ann Steele, ashore on Cape Cod. Partial loss.
16. Sloop Belle, ashore on Cape Cod. Partial loss.
16. Sloop D. Ellis, ashore on Cape Cod. Partial loss.
16. Schooner Harwich, ashore on Cape Cod. Partial loss.
16. Schooner D. Parshall, ashore on Cape Cod. Partial loss.
16. Schooner Mary Haws, ashore on Cape Cod. Partial loss.
16. Schooner Rainbow, ashore on Cape Cod. Partial loss.
16. Brig Harp, ashore on Cape Cod. Partial loss.
16. Schooner R. B. Sumner, ashore on Cape Cod. Partial loss.
16. Schooner Peru, ashore in Vineyard Sound. Total loss.

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Sept. 21. Schooner ———, ashore at Plymouth. Total loss.
Nov. 28. Schooner Glide, ashore on Cohasset Rocks. Total loss.
Dec. 8. Brig Castilian, ashore on Nantucket. Partial loss.
20. Schooner Sally Badger, ashore at Scituate. Total loss.
24. Brig J. W. Havener, ashore at Wellfleet. Partial loss.

Schooner E. F. Lewis, ashore at Chatham.
Schooner Mary Ann, ashore at Chatham.
Schooner B. F. Sparks, Naushon. Total loss.
Bark Daniel Webster, ashore at Woods' Hole.
Schooner Seraph, ashore at Wellfleet.
Schooner Elect, Cotuit Point.
Schooner Golden Gate, Handkerchief.
Schooner Lookout, ashore at South Point.
Schooner Lion, ashore at South Point.
Schooner Mary F, ashore at Nauset.
Ship Oressa, ashore at Nauset. Total loss.

## 1859.

Jan. 7. Brig Thomas and Edward, on Cuttyhunk. Total loss.
8. Schooner Oregon, ashore on Cohasset Rocks. Total loss.
10. Schooner R. L. Kenny, ashore on Duxbury Beach. Total loss.
10. Schooner Sally Badger, ashore at Scituate. Total loss.
10. Sloop Escort, on Tuckernuck Shoal. Total loss.
28. Ship Roebuck, on Cohasset Rocks. Total loss.
Feb. 12. Schooner Chieftain, on Chatham Bar. Total loss.
14. Schooner Hope, on Race Point. Total loss.
28. Schooner Elizabeth Lord, at Scituate. Total loss.
Mar. 9. Brig M. S. Cousins, ashore on Race Point. Total loss.
23. Ship Shooting Star, on Tuckernuck Shoal. Partial loss.
April 1. Schooner Gazelle, ashore at Holmes' Hole. Total loss.
1. Schooner Sarah, on Nantucket Bar. Total loss.
1. Schooner Hartford, on Nantucket Bar. Partial loss.
3. Schooner Sarah Elwell, ashore at Holmes' Hole. Total loss.
23. Schooner Jenny Lind, ashore at Race Point. Total loss.
May 20. Schooner William Tyson, ashore on Noman's Land. Total loss.

Schooner David Lombard, on Shoals. Total loss.
Brig Elisha Doane, on L'Hommedieu.
Schooner G. Stratten, Sow and Pigs. Total loss.
Schooner Gen. Clinch, on L'Hommedieu.
Bark Howland, on Cape Cod. Total loss.
Schooner Oneco, on Hen and Chickens. Total loss.
Schooner Boston, ashore at South Point.
Schooner James Farewell, ashore at South Point.

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*A Schedule of* 108 *Shipwrecks occurring during the Years from* 1837 *to* 1860, *wherein the loss of Property is fully, and that of Life partially reported.*

SHIPS.

| Year. | NAME. | Where Wrecked. | Value. | Lives lost. |
|---|---|---|---|---|
| 1837, | Mercury, | South Point, | $125,000 00 | 4 |
| 1849, | Franklin, | Nauset, | 150,000 00 | 15 |
| 1849, | Cactus, | Tuckernuck, | 40,000 00 | 18 |
| 1853, | Mary Ann, | South Point, | 50,000 00 | 3 |
| 1854, | Forester, | Wellfleet, | 12,000 00 | 9 |
| 1857, | Orissa, | Nauset, | 71,000 00 | 3 |
| 1858, | Oressa, | Nauset, | 80,000 00 | – |
| | | | $528,000 00 | 52 |

BARKS.

| | | | | |
|---|---|---|---|---|
| 1848, | Kate Kearney, | Nauset, | $15,000 00 | – |
| 1850, | Oregon, | Nauset, | 60,000 00 | – |
| 1853, | Ida, | Cape Cod, | 15,000 00 | – |
| 1853, | Appleton, | Cape Cod, | 10,000 00 | – |
| 1855, | Edisto, | Nauset, | 50.000 00 | 4 |
| 1857, | Chester, | Chatham, | 50,000 00 | 4 |
| 1857, | Brothers, | South Point, | 50,000 00 | – |
| 1857, | Julia Ann, | Nauset, | 6,000 00 | – |
| 1857, | Inbad Sultan, | Nauset, | 150,000 00 | 7 |
| 1860, | Unknown, | South Point, | 90,000 00 | – |
| | | | $496,000 00 | 15 |

BRIGS.

| | | | | |
|---|---|---|---|---|
| 1837, | Ceylon, | Nantucket, | $30,000 00 | – |
| 1842, | Brutus, | Nauset, | 15,000 00 | – |
| 1842, | Unknown, | South Point, | 40,000 00 | – |
| 1844, | Frances and Louisa, | Nauset, | 8,000 00 | 2 |
| 1845, | Pactolus, | South Point, | 5,000 00 | 2 |
| 1845, | St. Thomas, | Nauset, | 10,000 00 | – |
| 1846, | Arcott, | Nauset, | 4,000 00 | – |
| 1847, | Orissa, | S. Point, Chatham, | 30,000 00 | 2 |
| 1848, | E. O. Holt, | S. Point, Chatham, | 4,000 00 | – |
| 1848, | Isabella, | S. Point, Chatham, | 20,000 00 | 2 |
| 1849, | Dracut, | Nauset, | 5,000 00 | – |
| 1849, | Warner, | Nauset, | 20,000 00 | 6 |

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*Schedule of* 108 *Shipwrecks*—Continued.

| Year. | NAME. | Where Wrecked. | Value. | Lives lost. |
|---|---|---|---|---|
| 1850, | Unknown, | Wellfleet, | $7,500 00 | – |
| 1850, | Unknown, | Wellfleet, | 7,500 00 | – |
| 1850, | Eagle, | Provincetown, | 15,000 00 | 15 |
| 1850, | California, | Nauset, | 9,000 00 | – |
| 1850, | Mount Vernon, | Wellfleet, | 4,500 00 | 8 |
| 1850, | Logan, | Wellfleet, | 10,000 00 | – |
| 1851, | Token, | Nauset, | 10,000 00 | – |
| 1851, | Unknown, | Nauset, | 25,000 00 | 15 |
| 1851, | Jane, | South Point, | 10,000 00 | – |
| 1851, | Huron, | Cape Cod, | 12,000 00 | – |
| 1852, | Callao, | South Point, | 2,000 00 | 3 |
| 1853, | Cordelia, | Nauset, | 35,000 00 | – |
| 1853, | Monte Christo, | Nauset, | 4,000 00 | – |
| 1855, | Mary Taylor, | South Point, | 10,000 00 | – |
| 1856, | Solomon Piper, | Race Point, | 15,000 00 | – |
| | | | $367,500 00 | 55 |

SCHOONERS.

| | | | | |
|---|---|---|---|---|
| 1839, | New Union, | Chatham, | $5,000 00 | – |
| 1839, | Oxford, | Chatham, | 3,000 00 | – |
| 1840, | J. Tolman, | South Point, | 3,000 00 | – |
| 1840, | Rispah, | South Point, | 1,500 00 | – |
| 1844, | Carribean, | South Point, | 2,000 00 | – |
| 1844, | Plover, | South Point, | 4,000 00 | – |
| 1844, | Lexington, | South Point, | 2,000 00 | – |
| 1844, | Diskau, | South Point, | 4,000 00 | 2 |
| 1844, | Aid, | South Point, | 2,000 00 | – |
| 1845, | Rappahannock, | Nauset, | 4,000 00 | – |
| 1847, | Harvard, | Nauset, | 50,000 00 | – |
| 1847, | Walcott, | Off Nantucket, | 40,000 00 | – |
| 1848, | Van Buren, | Nauset, | 3,000 00 | 3 |
| 1848, | Margaret Ann, | South Point, | 3,000 00 | – |
| 1848, | Cyrus Chamberlain, | Nauset, | 50,000 00 | 1 |
| 1849, | Unknown, | Monomoy Point, | 4,000 00 | – |
| 1849, | Goldhunter, | South Point, | 15,000 00 | 2 |
| 1850, | Dove, | Wellfleet, | 3,000 00 | – |
| 1850, | Seraph, | Chatham, | 6,000 00 | – |
| 1850, | Juno, | Hyannis, | 2,000 00 | 8 |
| 1850, | Anne, | Wellfleet, | 2,000 00 | – |
| 1850, | Hannah Jane, | Wellfleet, | 2,500 00 | – |
| 1850, | Flash, | South Point, | 2,000 00 | – |
| 1850, | George Savary, | Wellfleet, | 6,000 00 | – |
| 1850, | Golden Rule, | Wellfleet, | 5,000 00 | – |
| 1850, | Conway, | Wellfleet, | 2,000 00 | – |
| 1851, | Unknown, | Truro, | 5,000 00 | 6 |
| 1851, | Unknown, | Wellfleet, | 5,000 00 | – |
| 1851, | Lightfoot, | South Point, | 3,000 00 | – |
| 1851, | Franklin, | Nauset, | 1,000 00 | – |

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*Schedule of* 108 *Shipwrecks*—Concluded.

| Year. | NAME. | Where Wrecked. | Value. | Lives lost. |
|---|---|---|---|---|
| 1852, | Vonda, | Chatham, | $5,000 00 | – |
| 1852, | North Star, | Chatham, | 3,000 00 | – |
| 1852, | Leopard, | Nauset, | 2,000 00 | – |
| 1852, | St. Pierre, | South Point, | 2,000 00 | – |
| 1852, | John Tyler, | South Point, | 6,000 00 | – |
| 1852, | James H. Boyd, | South Point, | 12,000 00 | 2 |
| 1852, | Kossuth, | South Point, | 8,000 00 | – |
| 1852, | James D. Paine, | South Point, | 4,000 00 | – |
| 1852, | D. Porter, | Nauset, | 2,000 00 | – |
| 1852, | Betsey, | Nauset, | 1,500 00 | – |
| 1853, | Orient, | Nauset, | 3,000 00 | – |
| 1853, | Anne, | Nauset, | 4,000 00 | – |
| 1853, | Lowell, | Cape Cod, | 5,000 00 | 4 |
| 1853, | E. Bray, | Cape Cod, | 10,000 00 | 3 |
| 1853, | Usher, | Cape Cod, | 70,000 00 | 2 |
| 1853, | G. K. Randell, | Cape Cod, | 5,500 00 | – |
| 1855, | Two Brothers, | Nauset, | 2,000 00 | – |
| 1855, | Frederick, | South Point, | 3,000 00 | – |
| 1855, | Sarah Ann, | Nauset, | 3,000 00 | – |
| 1856, | Capia, | South Point, | 10,000 00 | – |
| 1856, | Pool, | South Point, | 2,000 00 | – |
| 1856, | Milwaukie, | Great Round Shoal, | 9,000 00 | – |
| 1857, | Julia A. Rich, | West Chop, | 3,000 00 | – |
| 1857, | W. N. Freeman, | South Point, | 4,000 00 | – |
| 1858, | Eben Atkins, | South Point, | 4,000 00 | – |
| 1858, | Lookout, | South Point, | 2,000 00 | – |
| 1858, | Lion, | South Point, | 2,000 00 | – |
| 1858, | Mary F, | Nauset, | 2,500 00 | – |
| 1858, | Adrian, | Nauset, | 2,500 00 | – |
| 1859, | Boston, | South Point, | 2,000 00 | – |
| 1859, | James Farewell, | South Point, | 2,000 00 | – |
| 1860, | Anne, | South Point, | 3,000 00 | – |
| | | | $439,000 00 | 33 |
| | | SLOOPS. | | |
| 1844, | Hannah Maria, | Nauset, | $1,000 00 | – |
| 1848, | Rough and Ready, | South Point, | 4,000 00 | – |
| | | | $5,000 00 | – |

RECAPITULATION.

| VESSELS. | Amount of Loss. | No. of Lives Lost. |
|---|---|---|
| 7 Ships, | $528,000 00 | 52 |
| 10 Barks, | 496,000 00 | 15 |
| 27 Brigs, | 367,500 00 | 55 |
| 62 Schooners, | 439,000 00 | 33 |
| 2 Sloops, | 5,000 00 | – |

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*Coastwise Arrivals and Clearances at the Custom-house for the Port of Boston for Twenty Years from* 1840 *to* 1859, *both inclusive.*

| Year. | Arrivals. | Clearances. | Year. | Arrivals. | Clearances. |
|---|---|---|---|---|---|
| 1840, . . | 4,336 | 2,815 | 1850, . . | 5,978 | 3,086 |
| 1841, . . | 4,575 | 2,841 | 1851, . . | 6,334 | 3,181 |
| 1842, . . | 4,324 | 2,298 | 1852, . . | 6,286 | 3,291 |
| 1843, . . | 4,944 | 2,497 | 1853, . . | 5,904 | 3,277 |
| 1844, . . | 5,312 | 2,830 | 1854, . . | 6,480 | 3,451 |
| 1845, . . | 5,631 | 3,054 | 1855, . . | 6,271 | 3,268 |
| 1846, . . | 6,775 | 2,672 | 1856, . . | 5,971 | 3,055 |
| 1847, . . | 7,125 | 3,198 | 1857, . . | 5,740 | 2,597 |
| 1848, . . | 6,118 | 3,187 | 1858, . . | 6,354 | 2,525 |
| 1849, . . | 6,199 | 3,174 | 1859, . . | 8,415 | 2,958 |

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*Coastwise Arrivals at Boston from places South of that Port, for Fifteen Years, from* 1844 *to* 1858, *both inclusive.*

| | 1844. | 1845. | 1846. | 1847. | 1848. | 1849. | 1850. | 1851. | 1852. | 1853. | 1854. | 1855. | 1856. | 1857. | 1858. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nantucket, | 66 | 59 | 56 | 54 | 48 | 42 | 42 | 44 | 43 | 34 | 20 | 25 | 19 | 21 | 21 |
| New Bedford, | 31 | 30 | 28 | 16 | 8 | 9 | 10 | 14 | 8 | 15 | – | – | – | – | – |
| Providence, | 19 | 86 | 25 | 13 | 11 | 3 | 11 | 2 | 8 | 5 | – | – | – | – | – |
| Hartford, | 44 | 43 | 45 | 42 | 35 | 38 | 36 | 30 | 23 | 23 | 20 | 11 | 15 | 13 | 13 |
| New York, | 648 | 678 | 653 | 804 | 599 | 551 | 549 | 585 | 500 | 476 | 539 | 478 | 428 | 429 | 509 |
| Albany, | 242 | 246 | 287 | 265 | 219 | 216 | 202 | 222 | 168 | 124 | 160 | 120 | 203 | 87 | 220 |
| Rondout, | 21 | 46 | 56 | 64 | 51 | 55 | 69 | 130 | 134 | 142 | 120 | 76 | 99 | 87 | 123 |
| Philadelphia, | 889 | 1,036 | 1,067 | 1,507 | 1,500 | 1,351 | 1,397 | 1,531 | 1,838 | 1,556 | 1,590 | 1,407 | 1,557 | 1,496 | 1,894 |
| Baltimore, | 200 | 210 | 163 | 193 | 266 | 272 | 271 | 240 | 283 | 346 | 431 | 412 | 316 | 312 | 400 |
| Norfolk, | 121 | 125 | 107 | 75 | 128 | 157 | 97 | 69 | 99 | 70 | 108 | 82 | 56 | 33 | 57 |
| Richmond, | 85 | 114 | 94 | 74 | 61 | 97 | 59 | 67 | 78 | 89 | 72 | 53 | 83 | 63 | 79 |
| Fredericksburg, | 58 | 69 | 56 | 50 | 69 | 62 | 50 | 54 | 49 | 49 | 32 | 21 | 20 | 16 | 21 |
| Alexandria, | 46 | 49 | 29 | 38 | 41 | 37 | 25 | 83 | 65 | 117 | 114 | 112 | 154 | 71 | 182 |
| Rappahannock, | 34 | 41 | 27 | 59 | 19 | 17 | 5 | 5 | 7 | 4 | – | – | – | – | – |
| Wilmington, N. C., | 39 | 36 | 50 | 77 | 63 | 93 | 82 | 84 | 88 | 105 | 111 | 75 | 92 | 66 | 110 |
| Charleston, | 59 | 100 | 75 | 79 | 65 | 64 | 56 | 54 | 56 | 71 | 63 | 72 | 54 | 38 | 63 |
| Savannah, | 57 | 62 | 44 | 56 | 48 | 68 | 47 | 65 | 78 | 98 | 83 | 72 | 88 | 32 | 71 |
| Mobile, | 58 | 53 | 50 | 77 | 68 | 67 | 32 | 50 | 56 | 48 | 46 | 42 | 66 | 38 | 3 |
| New Orleans, | 173 | 165 | 195 | 242 | 276 | 241 | 161 | 153 | 156 | 162 | 128 | 167 | 209 | 180 | 203 |
| Washington, N. C., | 45 | 49 | 38 | 56 | 27 | 36 | 20 | 25 | 20 | 22 | – | – | – | – | – |
| Other places, | 281 | 245 | 389 | 430 | 499 | 483 | 452 | 518 | 640 | 628 | 1,051 | 758 | 606 | 680 | 1,069 |
| | 3,216 | 3,542 | 3,534 | 4,271 | 4,101 | 3,959 | 3,673 | 4,025 | 4,397 | 4,184 | 4,688 | 3,950 | 4,065 | 3,649 | 5,038 |



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*Arrivals at Gloucester, Salem, and Newburyport, from Southern Ports, for Five Years, from* 1856 *to* 1860, *both inclusive.**

| | 1856. | 1857. | 1858. | 1859. | 1860. | Total in Five Years. |
|---|---|---|---|---|---|---|
| Gloucester, . . . . | 61 | 71 | 108 | 156 | 100 | 496 |
| Salem, . . . . | 160 | 174 | 132 | 162 | 128 | 756 |
| Newburyport, . . . | 178 | 165 | 199 | 238 | 266 | 1,046 |

* This statement does not include all the arrivals, but is as perfect as our means of information enables us to make.

*Amount of Coal imported into the Port of Boston from Philadelphia, and other Southern Ports, for Twenty Years, from* 1840 *to* 1859, *both inclusive.*

| | Tons. | Bushels. | | Tons. | Bushels. |
|---|---|---|---|---|---|
| 1840, . . | 73,847 | 92,370 | 1850, . . | 289,571 | 52,375 |
| 1841, . . | 110,938 | 121,041 | 1851, . . | 361,073 | 80,880 |
| 1842, . . | 90,276 | 121,800 | 1852, . . | 431,270 | 14,000 |
| 1843, . . | 117,451 | 150,813 | 1853, . . | 362,006 | 46,000 |
| 1844, . . | 139,566 | 170,850 | 1854, . . | 373,601 | – |
| 1845, . . | 171,023 | 284,475 | 1855, . . | 387,259 | – |
| 1846, . . | 187,028 | 151,900 | 1856, . . | 411,093 | – |
| 1847, . . | 261,259 | 127,525 | 1857, . . | 371,926 | – |
| 1848, . . | 275,246 | 48,600 | 1858, . . | 417,333 | – |
| 1849, . . | 261,293 | 20,800 | 1859, . . | 570,325 | – |

*Number of Bales of Cotton imported into the Port of Boston during the Thirty Years from* 1830 *to* 1859, *both inclusive.*

| | | | |
|---|---|---|---|
| 1830, . . . . | 46,203 | 1845, . . . . | 187,619 |
| 1831, . . . . | 53,810 | 1846, . . . . | 193,459 |
| 1832, . . . . | 60,011 | 1847, . . . . | 198,932 |
| 1833, . . . . | 54,139 | 1848, . . . . | 339,958 |
| 1834, . . . . | 60,312 | 1849, . . . . | 270,693 |
| 1835, . . . . | 80,709 | 1850, . . . . | 195,076 |
| 1836, . . . . | 82,885 | 1851, . . . . | 204,232 |
| 1837, . . . . | 82,684 | 1852, . . . . | 281,166 |
| 1838, . . . . | 96,636 | 1853, . . . . | 266,364 |
| 1839, . . . . | 94,361 | 1854, . . . . | 277,490 |
| 1840, . . . . | 138,709 | 1855, . . . . | 285,400 |
| 1841, . . . . | – | 1856, . . . . | 327,554 |
| 1842, . . . . | 131,860 | 1857, . . . . | 211,604 |
| 1843, . . . . | 151,090 | 1858, . . . . | 279,523 |
| 1844, . . . . | 175,529 | 1859, . . . . | 323,693 |

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Number of Barrels of Flour imported into the Port of Boston from the following Southern ports, for the year 1859 :*

| | |
|---|---|
| New Orleans, | 153,045 |
| Alexandria, | 12,162 |
| Richmond, | 49,945 |
| Philadelphia, | 112,519 |
| Baltimore, | 133,533 |
| Fredericksburg, | 6,450 |
| New York and Albany, | 65,457 |
| Other places, | 12,651 |

Number of Bushels of Corn imported into Boston from the following Southern Ports, during the year 1859 :*

| | |
|---|---|
| New Orleans, | 10,155 |
| Virginia, | 433,685 |
| Maryland, | 487,408 |
| Pennsylvania, | 466,238 |
| Delaware, | 113,828 |
| | 1,511,314 |

Number of Hides imported into the Port of Boston from the following Southern Ports, during the year 1859 :*

| | |
|---|---|
| New Orleans, | 108,865 |
| Other Southern Ports, | 70,473 |
| | 179,338 |

Naval Stores in Barrels imported into the Port of Boston from North Carolina and elsewhere, consisting of Rosin, Turpentine, Tar, Pitch, &c.,* . . . . . 122,984

Casks of Rice imported into the Port of Boston, from Charleston and elsewhere, during the year 1859,* . . . . . 8,856

Sugar, Molasses, and Tobacco, imported into the Port of Boston, during the year 1859, from the Southern States, as follows :*

| | |
|---|---|
| Sugar, hhds. | 8,711 |
| " bbls. | 31,125 |
| " bags, | 3,551 |
| Molasses, hhds. | 9,571 |
| " bbls. | 5,118 |
| Tobacco, hhds. | 1,477 |
| " bales, | 7,382 |
| " boxes and kegs, | 64,316 |

* Mr. Merrill's Report, Pub. Doc. 34, 1860.

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## [II.]

COAST SURVEY OFFICE, June 5, 1860.

DEAR SIR,—According to the arrangement between us when you were in Washington, I have directed H. L. Whiting, Esq., Assistant U. S. Coast Survey, to go over the route of Major Perault's Survey, between Cape Cod and Buzzard's Bay, to ascertain what new surveys, if any, are required as preliminary to an examination for the canal route. He has made an estimate of $100 for this examination, and will furnish accounts in the Coast Survey form, for the expenditures. Will you be so good as to make to Samuel Hein, Esq., General Disbursing Agent U. S. Coast Survey, Washington, a remittance of this amount, that he may put Mr. Whiting in funds.

Yours respectfully,

A. D. BACHE.

Hon. TAPPAN WENTWORTH, *Chief Commissioner, etc.*

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COAST SURVEY OFFICE, June 26, 1860.

DEAR SIR,—I am ready now to send a party to observe the tides and currents off the termini of the proposed canal between Cape Cod and Buzzard's Bay. It will be convenient and save time and expenses if the schooner Bailey stop in Buzzard's Bay, as she goes to Boston Harbor to survey. Assistant Henry Mitchell, who will have charge of these observations, estimates the cost at $531, including the incidental expenses of the vessel and the employment of the observers. The vessel and equipments and salary of assistant are not a subject of charge. I would respectfully request that the sum thus estimated may be advanced to Samuel Hein, Esq., General Disbursing Agent of U. S. Coast Survey, Washington, to meet Mr. Mitchell's expenditures, for which he will return you vouchers in duplicates in the usual Coast Survey form, giving receipts for the actual expenditures.

Very respectfully yours,

A. D. BACHE, *Superintendent.*

Hon. TAPPAN WENTWORTH, *Chief Commissioner, etc.*

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COAST SURVEY OFFICE, July 9, 1860.

DEAR SIR,—I have to acknowledge the receipt of yours of July 6th, with enclosed draft for $531, which has been handed to Mr. Hein, the General Disbursing Agent of the Survey. I will advise you when I can come to Boston, my arrangements made last week having of necessity been postponed.

Yours respectfully,

A. D. BACHE, *Superintendent.*

Hon. TAPPAN WENTWORTH, Boston, Mass.

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NEAR LACONIA, N. H., July 20, 1860.

DEAR SIR,—Will you meet the Commissioners on Boston Harbor, whom you have also called in, in regard to the Cape Cod Canal, on Wednesday or Thursday morning, as may be most agreeable to you, say at half-past nine or ten o'clock, at the Revere House, Boston?

Yours respectfully,

A. D. BACHE.

Hon. TAPPAN WENTWORTH, Lowell, Mass.

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BOSTON, August 23, 1860.

DEAR SIR,—The Commission, concurring with Mr. Mitchell in the views expressed by him of the great importance of observations of the motion of the shingle on the beach near Scusset entrance, recommend that the sum which he names as necessary to make the observations be placed at the disposal of the Superintendent of the Coast Survey, for the purpose.

On behalf of the Commissioners and by their authority,

A. D. BACHE, *Supt. U. S. Coast Survey.*

Hon. TAPPAN WENTWORTH, *Chief Commissioner on Cape Cod and Buzzard's Bay Canal, etc.*

BOSTON, August 22, 1860.

DEAR SIR,—I respectfully ask that an additional sum of one hundred and thirty dollars ($130) may be placed at my disposal, for a further examination of the eastern terminus of the proposed Cape Cod Canal.

On the occasion of a late visit of the Commissioners to the shore of Barnstable Bay, the question was discussed, what will be the exposure of the terminus of the canal to the destructive effects of shingle and sands driven along the coast by north-east gales. I stated at that time

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that your instructions directed me to make inquiries of this kind during the course of our study of the tides and the coastwise currents, but the entire absence of easterly gales and stormy weather of any kind—peculiarly favorable as it had been for the general scheme of our investigations—had afforded us no opportunity of recording the least violent action upon the beach.

The information we were able to obtain from consultations with the intelligent residents of the neighborhood is ill-defined and contradictory. These persons agree in general statements of large changes in the beach ridges and bars, due to storms, and describe violent movements of the shingle witnessed during heavy gales,—movements which they believe have formed the dry bar of Scusset River and caused the shifting of Sandwich Harbor mouth. But this kind of information, especially when the memory confounds the gradual and sudden changes of many years together, is unreliable—sometimes exaggerated and sometimes influenced by the bias of self-interest. The only safe and just course, it appears to me, lies in the careful collection of *numerical data* from actual measurements.

The question whether the mouth of the proposed canal will stand in danger of encumbrance from shingle, or of being cut off from the ocean by sand bars, is one that ought to be put *now*, before the first stone is laid. The data obtained from the work of a single storm, by our systematic methods, may give us the entire source of all difficulties, and perhaps suggest to your learned Commission a simple plan for overcoming them, thus removing the last argument against this noble enterprise.

I should regret exceedingly to close our investigations without these essential inquiries, especially after the success which has attended other portions of our observations.

Very respectfully yours,

HENRY MITCHELL, *Assistant, C. S.*

Prof. A. D. BACHE, *Supt. U. S. Coast Survey.*

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BOSTON, September 4, 1860.

DEAR SIR,—The Commissioners request me to communicate to you the following points in relation to the proposed canal to connect Cape Cod and Buzzard's Bays:—

1. The question of the outlet of the canal on Buzzard's Bay, being one of more or less dredging simply, they do not consider it essential to have a resurvey of that outlet, deeming the Coast Survey charts already

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made sufficient, with the new current operations, to lead to safe conclusions.

2. On the Cape Cod side the case is different. A survey of some two and a half square miles, including about fifty miles of soundings, will be needed to settle the questions relating to a breakwater, to form an artificial harbor on that side. The cost of this by the Coast Survey will be about $500, and the Commissioners desire to know whether the Committee will undertake this by their own engineer, or whether they desire it to be done by the Coast Survey; and if by the Coast Survey, that the funds be placed as early as convenient at the disposal of the Superintendent, that the work may be executed, if possible, before the season closes.

Very respectfully, yours,

JOS. G. TOTTEN.

Hon. TAPPAN WENTWORH, Lowell, Mass.

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LOWELL, Sept. 12, 1860.

DEAR SIR,—Your suggestion to have a survey of two and a half square miles, including about fifty miles of soundings, to settle the questions relating to a breakwater to form an artificial harbor in Barnstable Bay, has been laid before our Committee, and it was voted that the same should be done by the Coast Survey. The Committee will have another meeting on Saturday next, when it is proposed to provide the required funds ($500) for that purpose.

The funds will be transmitted to the Coast Survey Office as soon as provided, in accordance with the system which has been adopted.

Your obedient servant,

TAPPAN WENTWORTH.

Gen. J. G. TOTTEN.

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BOSTON, September 5, 1860.

DEAR SIR,—I inclose herewith the receipt of Samuel Hein, Esq., General Disbursing Agent U. S. Coast Survey, for one thousand dollars ($1,000) on account of the survey of canal route between Cape Cod and Buzzard's Bays.

Yours respectfully,

A. D. BACHE, *Supt. U. S. Coast Survey*

Hon. TAPPAN WENTWORTH, Lowell, Mass.

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COAST SURVEY, STATION NEAR FITCHBURG, MASS., Sept. 15, 1860.

DEAR SIR,—I have to acknowledge the receipt of yours of Sept. 12th, accepting the proposition of the Commissioner for the Cape Cod hydrography, and would request the usual course in regard to funds, so that all the accounts may go through Mr. Hein. The Committee will be furnished with copies of the field notes.

Yours respectfully,

A. D. BACHE, *Supt.*

Hon. TAPPAN WENTWORTH, Lowell, Mass.

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BOSTON, October 31, 1860.

DEAR SIR,—Your note of October 25th, addressed to Mr. Hein, and the draft for $500, have been duly forwarded to him.

Yours respectfully,

A. D. BACHE, *Supt.*

Hon. TAPPAN WENTWORTH, Lowell, Mass.

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COAST SURVEY OFFICE, June 20, 1860.

DEAR SIR,—I beg leave to acknowledge the receipt of one hundred dollars ($100) from Hon. Tappan Wentworth, being an advance for expenditures to be incurred in examinations for Cape Cod Canal.

Yours respectfully,

SAM'L HEIN, *Disbursing Agent, Coast Survey.*

Prof. A. D. BACHE, *Supt. Coast Survey.*

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WASHINGTON, July 9, 1860.

($531.) Received from Hon. Tappan Wentworth five hundred and thirty-one dollars, for expenditures for Cape Cod and Buzzard's Bay Canal.

SAM'L HEIN.

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COAST SURVEY OFFICE, Sept. 3, 1860.

($1,000.) Received from Hon. Tappan Wentworth, through Prof. A. D. Bache, one thousand dollars, for expenditures on survey of canal route from Barnstable to Buzzard's Bay.

SAM'L HEIN, *Disbursing Agent, Coast Survey.*

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COAST SURVEY OFFICE, WASHINGTON, Sept. 24, 1860.

($137.) Received from Hon. Tappan Wentworth check on Bank of Commerce, Boston, for one hundred and thirty-seven dollars, for expenses of examining depth of sand, &c., &c., for Cape Cod Canal.

SAM'L HEIN, *Disbursing Agent, Coast Survey.*

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BUREAU OF TOPOGRAPHICAL ENGINEERS,
WASHINGTON, August 28, 1861.

Mr. TAPPAN WENTWORTH, *for Committee of Mass. Legislature, Lowell, Mass:*

SIR,—Your letter of the 21st inst., under cover to Brigadier-General Totten, is received. As requested, a tracing of "a plan and profile of a survey and level for the proposed canal between Buzzard's and Barnstable Bay, surveyed September, 1818, by L. Baldwin," is forwarded to your address by the mail of this day.

It is not known whether Mr. Baldwin accompanied his survey with a report. If, on searching through the old papers in the bureau, one should be found, a copy will also be sent to you.

Very respectfully, your obedient servant,

HARTMAN BACHE, *Lt. Col. Top. Engineers.*

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BOSTON, MASS., Nov. 9, 1860.

DEAR SIR,—I am requested by the Advisory Council of the Committee on the Buzzard's and Barnstable Bays Canal to say to you, that the surveys which they proposed to you to have made are completed. They have now at your disposal—

1. A topographical survey, including the entire valley of the Monumet and Scusset Rivers, on a scale of $\frac{1}{10000}$, about $6\frac{1}{3}$ inches to the mile, upon which the horizontal curves are drawn at every five feet of elevation, and referred to points upon the railroad track, by Sub-Assistant W. H. Dennis, U. S. Coast Survey. This map requires yet some lettering, but will be completed in a few days.

2. A tracing from the coast survey chart of the north-east part of Buzzard's Bay, included between Wenaumet and Tempe's Knob Necks and the approaches. Hydrography by Lieut. George S. Blake, U. S. N., Assistant U. S. Coast Survey.

3. A tracing from the council chart of Barnstable Bay, from about three-quarters of a mile south to one and three-quarters miles north, of the mouth of Scusset River. Hydrography by Lieut. Com. J. Wilkinson, U. S. N., Assistant U. S. Coast Survey.

4. Records of a series of tidal and current observations in Buzzard's Bay and in Barnstable Bay, by Assistant H. Mitchell, U. S. Coast



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Survey, and of investigations on drifts. The report of Assistant Mitchell, which requires considerable calculations and many diagrams, is not yet completed, but will probably be presented in about a fortnight.

These surveys and observations will furnish all that is needed as preliminary to the engineering, unless you desire a line of levels to be run by your own engineer, connected at the two extremities with Mr. Dennis' and Mr. Mitchell's beach-marks.

With those before us, we shall prepare our report, which we expect to submit to you in a few weeks. In this report we shall speak strongly in favor of the desirableness and practicability of a ship canal through the remarkable gorge in which the Monumet and Scusset Rivers run their head-waters, almost interlocking. The next step will be to employ an engineer of the first class to prepare the detailed projects for the canal; to examine the engineering questions which our report or his own studies will raise, and to prepare an elaborate project, with complete drawings, and estimates framed upon them.

When this project and these estimates are completed, we shall be prepared, if you desire it, to examine them in detail, and also to give our advice on any other matter in regard to which you may wish to consult us. I have the honor to be, very respectfully,

Your most obedient servant,

JOS. G. TOTTEN.

Hon. TAPPAN WENTWORTH, *Chairman of the Committee on the Canal between Buzzard's and Barnstable Bays*, Lowell, Mass.

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WASHINGTON, Dec. 17, 1860.

DEAR SIR,—I enclose herewith a resolution of the Advisory Council in relation to a series of observations on the temperature of air and water, etc., during the present winter, and shall be glad to have them commenced as early as practicable after the approval of the Committee and the provision of the means required.

Yours respectfully, A. D. BACHE, *Supt. U. S. Coast Survey.*

Hon. TAPPAN WENTWORTH, Lowell, Mass.

*Resolved*, That the Advisory Council of the Joint Committee of the Massachusetts Legislature on the subject of a ship canal to connect Barnstable Bay and Buzzard's Bay, recommend to the Committee to provide for a series of observations, under the direction of the Superintendent of the Coast Survey, on the temperatures of air and water, of the weather, and of the ice, near the eastern and western termini of the proposed canal to connect Barnstable and Buzzard's Bays, during the present winter, at a cost not to exceed one hundred and fifty dollars.

JOS. G. TOTTEN.

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## [III.]

NEW YORK, June 10, 1776.

SIR,—Congress having requested my attendance in Philadelphia, I was in that city when your letter of the 11th ultimo came to this place,—this day's post, therefore, affords me the first opportunity of acknowledging the receipt of it.

I am hopeful that you applied to General Ward, and have received all the assistance that Mr. Machin could give, in determining upon the practicability of cutting a canal between Barnstable and Buzzard's Bay ere this, as the great demand we have for engineers in this department, Canada, &c., has obliged me to order Mr. Machin hither to assist in that branch of business.

I thank you most heartily for your kind congratulations on the departure of the troops from Boston, and am, with very great esteem,

Sir, your most obedient, humble servant,

GEO. WASHINGTON.

Hon. JAMES BOWDOIN, Boston.

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## [IV.]

## REPORT

*Of the Advisory Council of the Joint Committee of the Massachusetts Legislature on the subject of a Ship Canal to connect Barnstable Bay and Buzzard's Bay.*

General TOTTEN,
Professor BACHE,
Captain DAVIS,
*Advisory Council.*

The undersigned, United States Commissioners for Boston Harbor, having been called upon by the Joint Committee of the Legislature on the Cape Cod Canal, to direct the necessary survey and examinations, and to act as an advisory council, have the honor to submit the following Report:—

The subject-matter of this Report has been treated in its principal features by the special joint committee of the legislature in March last. In Public Document No. 34 of the House of Representatives, containing that paper, are introduced the reports from the Topographical Bureau and Board of Internal Improvement of the years 1825–29, in which the general question of construction is fully and ably discussed. The commercial and economical statistics belonging to the subject have acquired extraordinary interest and value since that period; so many and great have been the changes in these respects, that it is hardly to be regretted that the canal was not undertaken upon the plan then thought adequate to meet the demands of commerce.

The services of the undersigned, however, seem to have been called in under that clause of the Resolve which gives the Committee "full power and authority—to employ engineers, make surveys and soundings—examine localities, and to do all other things necessary to enable them to determine on the *practicability* of constructing such channel or canal." We (the undersigned) believe that our assistance and counsel are particularly required in the performance of such labors as come more immediately under our professional experience and direction, and we have proceeded accordingly. We have endeavored to supply some information and suggestions of intrinsic value for this or any future scheme; and we have separated them into *Hydrographical* and *Topo-*

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*graphical*, embracing in the latter the little we have to say upon the topic of construction.

These heads of our Report, it must be said, are rather formal than essential; they easily intrench upon each other. While they are adopted for convenience, they will not prevent us from pursuing the connections and mutual relations of the two divisions whenever they may rise to view.

Under the *Hydrographic* head the leading topic is obviously the tides, for they give to the project under consideration features that are quite new and unparalleled in the history of canal construction. The two seas which are to be connected by this channel possess tidal systems so essentially distinct from each other, that we have to deal with heads of water undergoing perpetual changes and alternations.

Canals have been built in Europe, connecting arms of the sea visited by differently modified propagations of the tide-wave, presenting, however, but small contrasts of forms compared with those of the tide-waves of Barnstable and Buzzard's Bays. The latter, though probably derived from a common source, have separated at a point so distant, and have subsequently traversed such dissimilar avenues, that, as they finally appear at the termini of the proposed canal within about six miles of each other, their resemblance is not closer than that of tides of different continents.

The problems of construction growing out of the peculiar conditions here referred to, will greatly exercise the skill of the engineer. It is evident that reliable data for the solution of such problems can only be derived from the most careful and accurate tidal observations. An examination of the tidal data given in the memoir of 1825 and the report of 1827, proves, we think, that the engineers of that time did not establish their gauges in positions suitable for observing the entire range of the tide, because the relative heights of the bays recorded by them do not agree with those deduced from the general tidal results of the Coast Survey.

Early in July, Mr. Henry Mitchell, Assistant in the Coast Survey, was directed by the Commission to proceed to Cape Cod, with instructions to establish tide-gauges at the termini of the proposed canal, and to conduct a series of simultaneous observations upon these gauges for one month. This work was successfully executed. The gauges were erected in situations fully exposed to the action of the tide; the low-water gauge upon the Scusset shore being placed quite beyond the breakers, and secured to a frame-work of iron, devised for this special purpose, which proved capable of resisting the dash of the sea. The gauges consisted of graduated staves with glass tubes inserted. In these tubes, to which the water gained access by openings below the reach of

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ordinary swells, floated colored glass bubbles, the positions of which the observers were required to note. The observations were made at intervals of from two to five minutes, commencing not less than an hour before, and continuing for the same time after each stand of the tide; and thus we have obtained the means, not only of ascertaining the tidal establishments and ranges for the two bays, but also of determining the amount of maximum variation of elevation, the dates of these phenomena being referred to the corresponding periods of the moon's meridian transit.

On working up these observations, a very curious fact has been discovered—that, by reason of the distorted form of the Buzzard's Bay tide-wave, the relative elevations of the two bays undergo unequal changes upon ebb and flood; in other words, the maximum slope from Barnstable Bay to Buzzard's Bay, occurring about one hour after the high-water of the former, is in excess of the reverse inclination, which reaches its maximum about six hours after. If these two bays were connected by a canal, allowing an unobstructed passage to the currents, it would be found that the stream flowing westward would be of less duration, but greater velocity, than that pursuing the opposite course. The greatest elevation observed for Barnstable Bay, above Buzzard's Bay, fell little short of eight feet, while the former never fell much more than six feet below the latter.

Another interesting conclusion to which we have been led is this—that *within a certain limit, the greater the transverse section of the free canal, the more rapid will be the flow through it.* This follows from the facts that the tidal heads are inexhaustible, and that no diminution of fall can take place unless the connecting channel be sufficiently large to allow an interference of tide-waves, like that which now takes place between these same tides at the junction of Nantucket and Vineyard Sound and in Muskeget Channel, where the waves propagate themselves several miles beyond their points of interference, and thus reduce the contrast of heights. If we assume the difference of elevation to be from five to seven feet, the current (the sections to be mentioned hereafter) engendered in the proposed ship-canal would not exceed from three to four miles per hour; it sometimes reaches nearly three miles per hour off West Chop, where the tide-waves cross each other in eleven fathoms of water.

The tidal party was also instructed to make an examination of the currents in portions of the two bays contiguous to the outlets of the proposed canal; and the schooner Bailey was supplied by the Superintendent of the Coast Survey, to be used in this undertaking. Seven stations were occupied, at each of which observations were made at different depths, and recorded half-hourly for twenty-five hours. Four

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of these stations were appropriately chosen at the head of Buzzard's Bay, and three in Barnstable Bay. In the former, no results of importance were obtained, this region being remarkably free from strong currents in the dry season. In the latter, the discovery of a coast current gave peculiar interest to the observations. This current sweeps along the western shore of the bay, pursuing a northwardly course; it is feeble at the outlet of the canal, but it gathers strength farther north, where, according to the observations, it slackened only for about two hours at the time of most rapid rise of tide. The most singular feature, perhaps, of this coast current that fell under the observer's notice, was its very low temperature, the mean value of which, for the whole series of observations, was fifty-four degrees Fahrenheit—nineteen degrees lower than the mean temperature of the water of Black River Harbor at the same period. The air in the neighborhood of this current is sensibly chilled; so much so that, during the two months in which the observations were included, (July and August,) the mean temperature at Scusset was three degrees lower than that at Black River Harbor—a very considerable difference, when we consider that the latter place is on the windward side of the isthmus at this season, and that the stations were but six miles apart.

The changes in the elevation of the beach along the shore of Barnstable Bay were studied, by repeating long lines of levellings after three easterly storms; and the movements of shingle were determined by recording the changes in the positions of some articles deposited for this particular purpose on the beach, such as could be readily distinguished from the natural material. The observations were continued quite late in the autumn, but no very heavy storms having occurred, the results do not embrace extreme cases. The changes in the elevation of the beach were found to be very small, compared with those that have been heretofore observed upon exterior coasts. This is a consequence, chiefly, of the less yielding character of the shore than that of the coast generally; at the same time, we are convinced that the sea never does acquire as much power in this bay as upon the open coast. Mr. Mitchell's observers made frequent records of the height of the swell upon the outside of the tide-gauge; from these it appears that in fine weather the swell rose and fell but one-tenth of a foot, but a fresh breeze from the north-east increased the rise and fall to two feet. The least swell ever noted by the Coast Survey off the coast of New Jersey was seven-tenths of a foot, and off Nantucket, one foot. The swell of Barnstable Bay continues but a few hours after the wind has died away or ceased to blow from seaward.

The information collected by Mr. Harrison, Assistant Coast Survey, who executed the topographical survey of the vicinity of Scusset River and

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of all that region embracing the possible terminus of the proposed canal, is to the effect that although there are temporary changes in the shore-line, yet there has been no important alteration in the general trend of the coast during the period of man's recollection. The face of Peaked Cliff, which abuts directly upon the shore about three miles above the mouth of Scusset River, and also Long Cliff still farther off, both suffer more or less degradation, under the influence of north-east storms. The progress of these ravages is marked by the falling into the sea of trees from the summit of Long Cliff, and by the removal inland of the shore boundaries of wood lots. The shingle strewn along the bay-shore is set in motion by the same storms; and since, on these occasions, the sea impinges obliquely upon the beach, the stones and sands are driven to the southward. In this fact, we have an explanation of that movement of the mouth of Scusset River, of which we have elsewhere spoken; and concerning which we may add, that this shifting process is said to occupy about fifty years; that the last time the river broke through the sand-ridge was in the year 1823, and that it is now working to the south-east. The Scusset beach is somewhat sheltered from north winds by Monumet Point, and from north-east and still more easterly winds, by the extremity of Cape Cod. Wrecks are not frequent here. It is said that less than twenty sail of vessels, of all kinds, have been lost in this place during the last fifty years. These losses occur most frequently in the winter months, when the very storms that occasion them, assisted perhaps by in-shore currents, drive the wrecks, which are mostly coasters, farther up the bay.

The requisite soundings in this vicinity were executed by Lieutenant-Commanding John Wilkinson, U. S. N., Assistant Coast Survey. Their utility as a guide to the engineer, in such exterior constructions as we shall hereafter refer to, is too obvious to be dwelt upon. It is the prevailing opinion, as we learn from a letter of Captain Pelham Gibbs, an intelligent witness to whom we are much indebted for information and assistance, that there is good holding ground in a depth of six fathoms. The surveying party, however, in the Coast Survey schooner Bailey, report insecure holding ground at their stations in Barnstable Bay in this depth of water; but they observed that farther out, and beyond the seven fathom curve, the bottom was sticky—a term by which safe anchorage is distinguished.

Captain Wilkinson's examinations settled this matter conclusively. He finds sticky bottom, also, in seven fathoms; and this, therefore, we communicate as our present result, notwithstanding the difficulty in reconciling this conclusion with the direct and circumstantial testimony of Capt. Gibbs and his associates.

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Captain Wilkinson's examination will be repeated next season, when suitable borings will be made.

We said in the beginning of this Report, that we should include under the head of *Topography*, into which we are now entering, whatever we had to say upon the subject of construction. This last is but little in amount, and somewhat desultory in arrangement. It is not our intention to enter into all the particulars embraced in the execution of this project; in fact, it will be impossible to do so without adding a minute and protracted inspection of the ground to a study of the horizontal curves. It will be the special duty of the civil engineer, employed by the Committee, to furnish a project, accompanied with such estimates, and details of execution, as will enable the Committee to form a clear conception of the whole subject; and this duty will, probably, occupy not less than a year of his time, whatever accomplishments and assiduity he may bring to his task.

Upon the appointment of the engineer we have only one word to say, but that is a word of importance. The civil engineer employed by the Committee should be a person who stands at the very head of his profession. His ability and his authority should be undoubted. It is very certain that the Committee will be obliged to offer the largest compensation for the services of such a person; but, whatever is spent in this way, will be more than repaid by economy in administration, and especially, in what relates to a proper adjustment of the different parts of the work, by which, changes of plan are avoided.

But whilst it is not our intention to anticipate the plans and conclusions of your engineer, we shall offer a few suggestions, to which, if they meet your approval, you may give the form of instructions, or at least, present them as points for consideration, when the final plan comes up for decision. We will proceed to make these suggestions without further preface.

*a.* The engineer may find it very advantageous to occupy in part, or even to a considerable extent, the bed of the Monumet River—and perhaps that of the Scusset, also. To this end, it may be useful or requisite to open just enough of the eastern portion of the canal, to turn in that direction the waters coming from Herring Pond.

*b.* By turning the Herring Pond waters eastward, and temporarily damming the mouth of the Monumet River, a dry bed, (excepting springs,) will be left to work in, and the amount of excavation will be greatly reduced.

*c.* Taking into consideration the form of the bottom in Barnstable Bay, and the most convenient and suitable place for an anchorage; having in view the propriety of making an inner basin at that end, and



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also the shorter route; the engineer may find it well to turn the canal south, of *Sagamore Hill*, cutting through the low place in *Plymouth Neck*.

*d.* A basin may be cheaply excavated in the marshes on the Barnstable shore, wherever the mouth may be, within the probable range of selection. The material excavated will serve to make solid land in the neighborhood. The basin itself will answer a valuable purpose, as a place of resort in stormy weather for vessels bound either way.

*e.* A large harbor may be formed at the south-west end of the canal, by diking across from Agawam Neck to Hog Island, from that island to Marshne Island, from the latter to Toby's Island, and lastly, thence to the main. The canal tide-locks should be in the dike, between Marshne and Toby's Islands.

It may, possibly, be advisable to construct a small lock between Eggawau Neck and Hog Island, for the accommodation of the trade, and of the establishments within the harbor thus formed. Outside of the inclosed space, very little dredging will be required for the purposes of the canal; and none within. The water within may be kept at the high-water level of Barnstable Bay. There will be a great amount of water-power available at each of the dikes, if wanted.

*f.* The tide-locks in Buzzard's Bay will be of comparatively easy construction, and will not be liable to incumbrance by drift, or injury by the sea in a storm.

Those on the Barnstable side will demand in their planning, construction, and maintenance, all the resources of an able and experienced engineer. These last, moreover, must be protected on the north side by a jetty, if, for no other reason, to prevent the filling up of the canal by the sand-drift. By carrying this jetty out eastward for something like a mile, not only will the locks be covered, but a considerable lee will be afforded to vessels in north-east gales. If a still further covering to the anchorage should prove to be necessary, a separate breakwater might be built south-eastward of the jetty. The jetty itself must be as near the tide-lock as practicable, and, at the same time not so near as to be undermined by the dredging of the channel leading to the lock. It may be constructed by placing upon a grillage a ridge of stones, the slope of which upon the north side, gentle at first, would gradually incline less and less; as the work advances into the bay, the size of the stones will increase; the inside slope may be as steep as $\frac{1}{1}$. The grillage ought to be a little wider than the base of the ridge, and should be formed of round timbers laid lengthwise and across, and halved and bolted together; the timbers may be, from middle to middle, from three to three and a half feet, provided smaller timber be laid between, to prevent the stones from working through.

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*g.* The locks at both ends may have to be double or triple to expedite the transit of vessels. Their gates and walls must have an elevation adequate to the deepest draught through, that is to say—though a state of tide less full than the springs may have to be assumed for the level through the semi-lunation, it may be of importance to use the springs while they are on, because they will give an easier, as well as a greater draught. The minimum height should be the highest that, with the help of the delivery from Herring Pond, can be maintained during the period of neap tides; even a few inches would be worth gaining, by saving a large expenditure in excavation.

It will occur to an experienced engineer, that additional gates must be provided, to shut out from the locks storm-tides and waves; and, also, that it may be necessary to provide a frame-work of timber supported on piles, similar to the "timber platform, or jetty, projecting from the *west* wing-wall of Clachnacharry sea-lock, (Caledonian Canal,) for the purpose of easing the approach and departure of vessels. A row of pile fenders, supported by trussed framing, has also been driven round the extremity of the bank projecting from the *eastern* wing-wall, to prevent vessels grounding upon it by the action of the current." (Report of Commissioners, &c., 1843.) In our Report on the improvement of the Hell-gate passage, we recommended that certain piers "be faced with wood, and be provided with the spring fenders used at the steamboat ferries, and that their forms should correspond to the natural shape of the reef, by which means vessels coming in contact with them would be guided into the channel-ways." Expedients like these may be very conveniently resorted to on the eastern side of the canal, where the force of the sea, and the accumulated strength of currents in storms, are very much to be dreaded.

*h.* The surface breadth of the canal ought not, in our opinion, to be less than one hundred and fifty feet. The engineer may find the earth of such quality, as to justify a slope of $\frac{1}{1}$; or, on the other hand, it may require that the portion on the water's edge, if not the whole from bottom to top, be inclined at the rate of $\frac{2}{3}$. In any case, the sides should be paved with granite blocks one foot thick, laid in close contact, (perhaps in courses,) but without mortar.

*i.* Since we have in the site of the Cape Cod Canal, the manifest benefits of naturally level ground, in all respects advantageously situated, and not liable to disturbance by floods, the work is to be regarded as one of easy execution, and we may add, one of comparatively little cost.

Those great expenses which arise from an uneven character of the soil, and from the necessity for numerous locks, from large bridges, from

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tunnelling, from aqueducts of great length, find no place in this enterprise.

The preparation of the estimates based upon details, similar to those contained in the Report of General Bernard, belongs to your civil engineer, but the peculiarities of this, as far as we remember, entirely novel case, induce us to say a single word upon the subject of cost.

We have already spoken of the locks required, in consequence of the different levels of the sea at the two extremities of the canal. The mean of the daily maximum variations in the elevations of the basins, is 6.5 feet; and such a fall in the distance of eight miles, must, we need not say, be kept under control.

We might have given here the *extreme* difference, 8 feet: for it must be observed that this is a case in which *extremes*, and not *means*, enter into the argument. Hence arises the necessity for regulating the elevation of the water in the canal, and consequently, for determining the amount of excavation. If the canal were open at both ends, the amount of excavation would depend simply upon the depth to be maintained, at all times of tide, in the canal; or, in other words, if, at the stand of ebb tide, eighteen feet were assumed as the proper depth, the excavation would be eighteen feet below the plane of mean low-water. But the use of locks at the east and west termini, enables us to maintain a much higher elevation, and thus greatly to reduce the amount of excavation, and we may assume that elevation to be the mean high-water of neap-tides; profiting, as mentioned in *g*, by the convenient supply of Herring Pond, to make up for losses by evaporation, or otherwise.

Assuming, therefore, the mean height of the high tides of the neaps of Barnstable to be eight and a half feet above our plane of reference upon the Barnstable side, the bottom of the canal will be nine and a half feet below that plane of reference, the level of water being governed by the tides of Barnstable Bay.

Upon this subject of the depth of the canal, it would be absurd not to profit by universal experience, and particularly by the experience of the Caledonian Canal, which, in its *objects alone*, bears a near resemblance to our own. The former, like the Cape Cod Canal, unites two arms of the sea, and is designed to cut off a circuitous and dangerous navigation, particularly during the inclement season of the year. In 1838, thirty-five years after it was planned, Mr. Walker was obliged to recommend its being deepened, to admit vessels of seventeen feet draught, as a measure indispensable to its future prosperity and usefulness. A misapplied economy in this direction, will impair the profit and utility of the canal to-day, and bring reproach upon its projectors hereafter.

*k*. We have laid down the original route of the canal, given in Gen. Bernard's Report, upon the map executed by William H. Dennis, Sub-

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Assistant in the Coast Survey of the United States. This map is executed upon a scale of $\frac{1}{10000}$; it embraces an area of about $4\frac{1}{2}$ miles of finished topographical work, with $6\frac{1}{8}$ miles of shore line, 27 miles of roads, including the Cape Cod Railroad, and $23\frac{1}{2}$ miles of creeks, rivers, and ponds. The horizontal contour lines, drawn on the basis of a line of levels on the railroad running through the valley, represent the elevations at every five feet; the features of the country have been minutely detailed. We are satisfied that the original route is, in the main, correct. If any alterations are to be made in it, they must result from careful examinations on the spot, conducted by the engineer in person. We have no doubt that, in this manner, some changes may be made for the better. We aim at giving general ideas only.

*l.* We shall conclude these memoranda by saying to the Committee, that while we find it impossible to enter into the details of execution and accompanying estimates of this project, and recommend, therefore, the appointment of an engineer of established reputation, we shall continue to regard our services as entirely at the disposal of the Committee, either for the revision and examination of plans and calculations, or for advice in any part of the construction.

Our determination not to introduce into this Report details belonging to the constructing engineer, proceeds from a want of time, and not of interest in the work; we shall always be ready to act as consulting engineers.

The map referred to in *k* accompanies this Report; in connection with it, the following topographical description may have its value because coming from a different source, and not because it can add any thing essentially new to the natural description of this valley now in print; it is taken chiefly from Mr. Dennis' report to the Superintendent of the Coast Survey.

The valley through which the canal is to pass extends in length, from shore to shore, seven and three-quarter miles, and in a direct line from the waters of Buzzard's Bay to those of Cape Cod Bay, six and seven-eighths miles. The general direction of its course is north-east and south-west. It is bounded by two ranges of wooded hills, varying from sixty to one hundred and eighty feet in height; at its narrowest part, four miles from Back River Harbor, it is two hundred metres (220 yards) wide; and gradually expands from this point in both directions.

The bottom of the valley rises with regularity, to a height of twenty-five feet and a few inches; the greatest elevation is at a point distant five miles from Buzzard's Bay. From this point it descends to Cape Cod Bay, there being a difference of about two feet in height between the two extremities: the latter being the higher. The soil of the valley,

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of the same general character throughout, consists mostly of gravel; even under the marshy grounds, at a depth of two or three feet, it is gravelly. The growth is chiefly pine, with some spruce and scrub-oak. The land is poor, and is but little cultivated; the produce is mostly corn and potatoes; a few valuable cranberry bogs occur. There are also a few apple orchards. The average value of unsettled land is seven dollars per acre.

At the south-west end of the valley stands the small town of Monumet, with about two hundred inhabitants, a way-station on the Cape Cod Railroad; near the middle of the valley is North Sandwich, with about seventy-five inhabitants; and at the north-east end is Scusset, or West Sandwich, with one hundred and fifty inhabitants. The trees on the Monumet side do not flourish—the bleak south-west winter winds destroy them.

With the exception of three-quarters of a mile, the entire length of the valley is watered by two streams,—Monumet and Scusset Rivers. The former rises in the village of North Sandwich, whence it flows from a pond, into which the water of Herring Pond empties itself. It runs with a winding course for a distrance of four and three-quarters miles, and debouches into Buzzard's Bay, about a mile to the westward of Back River Harbor.

Its banks are for the most part marshy, and its average depth above Monumet bridge is about three feet. It does not appear to be materially affected in volume by heavy rains. Herring Pond covers an area of about three square miles, and is about twenty feet above high water. Numerous springs empty into Monumet River, and tide-water extends up its course about three and a quarter miles.

Nearly midway between Monumet and Scusset Rivers is the highest part of the valley.

Scusset River, about three-quarters of a mile from Monumet River, takes its rise in an artificial pond, formerly merely a boggy marsh. About three miles from the shore, it forms another pond at Scusset or West Sandwich, which is ten feet above Buzzard's Bay, and of an average depth of three feet. Thence it meanders through a level, marshy tract, covering an area of about a mile square, when it receives two principal branches, which are fed by innumerable creeks and ditches, being themselves also, for the most part, supplied by springs. These streams have sandy bottoms.

The river empties into Cape Cod Bay through a narrow ridge of sand hills, (dunes,) which separate the bay from the marsh. The mouth continually works to the south-east until it reaches the firm land near Sandwich, (where a point of rocks projects a short distance into the sea,) and then closes—the marsh becomes flooded, and the river bursts

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out again through the sand ridge, some distance above where it empties at present; and the process of working down the coast is renewed. Its depth at the mouth varies materially with the tides and winds; it is often fordable at low water.

Tide-water extends through the entire marsh up to the main road and first pond at Scusset, a distance of three miles.

At the south-west terminus of the canal, at Back River Harbor, the water included between Tempe's Knob Point and Wenaumet Neck, embracing an area of three square miles, affords a safe and secure harbor, with good holding ground of clay and gravel. Vessels drawing fourteen feet of water can come within four rods of the shore. The coast is rocky, and no material changes have been observed in the channel during the last twenty years. The prevailing winds from spring to autumn come from the west-south-west, and during the winter from west-north-west. The severest gales, however, are from the south-east; they occur in the spring and autumn.

Most of the trading vessels here are coasters—fore-and-aft schooners, and sloops; many barks and brigs go to Wareham, ladened principally with coal.

But we will not go farther into statistics like these, which falling under our immediate observation, are naturally mentioned; they have no place in this Report.

Our object has been to procure for the Committee information not within its own reach; and if we have been tempted, here and there, to add a word upon subjects not strictly within the province we had assigned to ourselves, it was with the hope of being useful.

You will find the maps and surveys accompanying this Report (see the appended list) not only convenient for your own reference, but of inestimable advantage to your engineer. That nothing may be wanting to assist him in his laborious task, we append herewith the entire Report of Mr. Mitchell, with the accompanying maps, tables, and diagrams. They will be more valuable to him, because such observations are not easily made, and when made, can seldom be so ably discussed.

We have the honor to be, very respectfully,

Your most obedient servants,

JOS. G. TOTTEN, *Bt. Brig. Gen. Top. Eng.*
A. D. BACHE, *Sup't. U. S. Coast Survey.*
C. H. DAVIS, *Com. U. S. N., Sup't. N. A.*

Hon. TAPPAN WENTWORTH, *Chairman of the Joint Committee of the Legislature on the Canal connecting Barnstable Bay and Buzzard's Bay*, Lowell, Mass.

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## APPENDIX.

1. Mr. A. M. Harrison's Map of the Valley of the Monumet and Scusset Rivers, described in report.

2. Mr. Dennis' survey of the mouth of the Scusset and the Barnstable shore within the probable limits of the eastern terminus of the Canal.

3. Hydrographic sheet of Lieut. Comg. J. Wilkinson, Assistant Coast Survey.

4. Buzzard's Bay, between meridians of Agawam and Monumet, and north of the parallel of S. Pocasset, by the U. S. Coast Survey.

5. Mr. Mitchell's report, with accompanying tables, diagrams, and maps.

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## [V.]

## REPORT ON THE TIDES, ETC.,

*Of Buzzard's and Barnstable Bays, near the outlets of the proposed Canal; to the Superintendent of the U. S. Coast Survey, by* HENRY MITCHELL, A. M.

DEAR SIR,—It is known as one of the developments of the Coast Survey, that the region off the south-eastern portion of Massachusetts is the scene of an interference of two branches of the tide-wave which are quite dissimilar in their establishments, ranges, etc. Weeweeder, on the south shore of Nantucket, and West Chop in Vineyard Sound, were found to be the points at which these waves interfered; while at Gay Head on the one hand, and Monomoy on the other, the waves were simple in character, and almost without trace of interference. At Gay Head, and at points along the coast to the southward, high water occurs at intervals of seven and eight hours after the moon's transit; while at Monomoy, and along our entire coast to the eastward, high water occurs at eleven and twelve hours after the moon's transit. Of the two tide-waves we have mentioned, the eastern is remarkable for its great increase of range as it passes into Massachusetts Bay; while the western wave varies its range but little from point to point along the adjacent coast.

In the study of the phenomena attending the meeting of these waves on the shores of Nantucket, it was ascertained, by careful levelings, that the two tidal systems have a common mean level; that is, that they rise and fall above and below a common plane.

The canal, proposed to connect Buzzard's and Cape Cod Bays, will unite at a new point the eastern and western tide-waves, and this too after they have been propagated for a considerable distance along peculiar paths, which have so altered their forms that they present, at the termini of the proposed channel, a singular contrast of times and heights.

In order to compare these tides for different phases of the moon, and under varying meteorological conditions, a month's observations were made at Back River Harbor and at Barnstable Bay simultaneously.

Table No. 1 contains the results from these observations, arranged in the usual Coast Survey form, except that the mean level of the sea is used as the plane of reference, instead of mean low-water, as in the tables for navigators. The reason for using this plane is, that it is



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supposed to be common to both Buzzard's and Cape Cod Bays, and offers a convenience in instituting comparisons of heights for the two basins. From this table we find that the tides on the two sides differ in time three hours and twenty-three minutes for high, and four hours eleven minutes for low water—the tides of Buzzard's Bay being earlier. The mean range for Back River Harbor is less than half that of Barnstable Bay, but the tides of the former, being more irregular, attain extreme ranges which exceed the mean proportion stated. It will be seen that, while the durations of rise and fall for Barnstable Bay are nearly equal—the tide-wave being quite normal and symmetrical—those of Back River differ about an hour and a half. This inequality of durations gives rise to a peculiarity of very great importance with reference to the proposed enterprise, which is this, that *the maximum differences of heights between the two bays, the one occurring on the flood, the other on the ebb, are not equal.* The rapid fall of the tide in Back River Harbor causes low water to occur in this basin soon after high water on the Barnstable Bay side; whereas, on the other hand, high water, being delayed at the former place, does not occur until the tide on the Barnstable Bay side has risen considerably. In Table No. 2 these maximum variations of water level between the two bays are given. Barnstable Bay, at certain periods, lies nearly eight feet above Back River Harbor, while the latter never attains a height much exceeding six feet above the former. The mean of the results is 4.66 feet for maximum height of Back River Harbor above Barnstable Bay, and 5.79 feet for the reverse relation of these basins. The maximum differences of altitude between the two basins occur, each day, at eleven hours and fifty-five minutes and eighteen hours and sixteen minutes after the moon's meridian transit. In the former case Barnstable Bay is higher, and in the latter, Back River Harbor. It is evident from this relation of water heads, that the currents which would traverse a free canal connecting the two bays, would be unequal; that running to the westward would have the greater velocity and the shorter duration. The meeting of these tide-waves in the Vineyard Sound is followed by currents whose velocities and durations stand in the relations I have predicted for the canal. Would not a channel once cut across the Cape Cod isthmus be maintained by the same natural causes that preserve the Vineyard Sound, or Muskeget Channel?

Diagram No. 1 exhibits the hourly relations of the tide-waves of Barnstable Bay and Back River Harbor, the observations being plotted above and below a common axis, which represents the mean level of the sea in either case. By inspection of this diagram we may perceive how greatly the relative water-levels of the two basins are complicated by the irregularities of the tide of Buzzard's Bay. Some small differences

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in the laws of daily irregularities of heights may also be noticed. Upon Diagram No. 2 I have plotted the heights of all the high and low waters observed, in order that the changes of half-monthly and daily inequalities may be exhibited. At the foot of this latter diagram the hour of the moon's transit is given each day. It will be noticed of either tide that there is a great inequality between the consecutive springs; that is, conjunction and opposition are for this month followed by very dissimilar tidal ranges. The spring-tide of Barnstable Bay for the 21st of July has a rise and fall of about twelve feet, while the next spring-tide, occurring early in August, has a range of ten feet. On the 17th of August our diagram shows the recurrence of the great spring. The phenomena accord well with the known laws of this eastern tide, which have been studied in former years from the Coast Survey observations at Boston. The Back River heights exhibit the general changes, we have referred to, in due proportion. The least ranges at neaps are about seven feet for Barnstable Bay, and three feet for Back River Harbor. Here again we notice the irregularities of the Buzzard's Bay tide, which are much greater than those of Barnstable Bay, and the diurnal inequalities of the former seem to follow the law but indifferently.

Notwithstanding the very great alterations of height and range, which these tides exhibit for different dates, it is a remarkable fact that the mean level of the sea suffers very little disturbance, especially in Barnstable Bay, where it rarely deviates for a tidal day more than two-tenths of a foot from the mean derived from the whole series. Table No. 3 gives these deviations from mean level for each day, from which it would appear that forty-eight hours' observations will suffice for the determination of mean level under ordinary circumstances. We do not trace in this table any considerable changes which are distinctly referable to the influence of winds, but it is proper to call attention to the fact that the period of our observations was one of remarkable quiet. It is probable that the mean level of Barnstable Bay is never greatly disturbed by the most violent winds, by reason of its great depth; but the more shallow waters of Buzzard's Bay may be crowded up by gales of wind from seaward. In waters of great depth all disturbances result in simple undulations, while in shallow bays the waves obtain a motion of translation which causes very great accumulations at certain points. It is a favorable circumstance that Buzzard's Bay is open to the sea in a direction from which gales are rarely known to blow. Generally speaking, the summer winds only blow up this bay.

Diagram No. 3 is a general exhibition of the half-monthly inequalities of intervals and heights, as derived from Table 4. The intervals of the Barnstable Bay tide are remarkably true to the law of half-monthly inequality given by a long series at Boston, while the intervals of Back

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River Harbor are decidedly irregular. This irregularity at Back River Harbor results from the fact that the tide is of small range and subject to a long stand, so that an accidental circumstance, as a squall or change of wind, may decide the time of greatest or least height upon the gauge. One or two inches of rise or fall due to wind would scarcely affect the times of high or low water in a tide of great range, like that of Barnstable Bay, for the normal rate of rise and fall is so great that but a few moments are occupied in an alteration of altitude quite exceeding any accidental or anomalous fluctuations of the sea. The half-monthly inequalities of heights for Back River Harbor follow far more regular curves than the intervals, the ratios being less disturbed by transient causes.

Notwithstanding the considerable vertical movements of the sea, as observed upon our gauges, the course of the tide-wave is so little impeded in either bay that the currents engendered in its progress are of the feeblest description; they, however, enter into relations with streams due to other causes, so that a consideration of them becomes necessary.

As the currents of the two basins present few points of comparison, I will take them up separately, in connection with other notes on local peculiarities.

*Buzzard's Bay.*—The feeble currents of this bay are called into action by delays and changes of the tide, together with small outflows of river waters. The currents of the upper portions of the bay were observed during periods of twenty-four hours, at four stations,—"No. 1, off Pocasset;" "No. 2, between Marshne Island and Bennett's Neck;" "No. 3, westward of Stony Point;" and "No. 4, at mouth of Back River Harbor." (See Diagram No. 4.) In Table No. 5, the general results from these observations are given, as far as can safely be relied upon. It will be seen that very great irregularities present themselves in the intervals at different dates, even when the stations are in close proximity. The cause of this is the uncertainty attending the observation of motions so very feeble that the effects of winds and other irregular causes cannot be distinguished from the normal action of the tides, etc. We may, however, arrive at some general conclusions from this table, among which are the following: The current intervals are about the same as those of the tide,—that is, slack current occurs about the time of tidal stand. The duration of slack water is about a half hour for stations in contracted portions of the channels. The maximum velocities of the currents are from one-quarter to one-half mile per hour, the ebb being usually in excess of the flood. The aggregate hourly movements, which, with sufficient accuracy, may be said to represent the daily scours, gives a predominance to the seaward current, except at the

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station "westward of Stony Point," where the flood was found predominant at the date of our observations. I cannot regard the result obtained at this station as entirely reliable, on account of the unfavorable weather which prevailed. Moreover, our observations were made at the season when the land streams are very low, so that more flood and less ebb are given by our table than could be supposed to exist under the average conditions for the whole year. In the dry season, Back River and Monumet River have more the character of tidal creeks than land streams; the former, at the time of our observations, was very scantily fed by land waters, if we may judge from the close approach to equality in the aggregates of ebb and flood, and from the great specific gravity of the water, which differed but little from that of the ocean.

We may remark, in general, that there is ordinarily at the head of Buzzard's Bay no scouring power capable of removing deposits of ashes from steamers, or sand ballast which might be thrown over from vessels.

The holding-ground is excellent in Back River Harbor, and sufficiently good in the basin outside. The islands and points which shelter the anchorages are high, so as to afford complete protection at all times. The shores are strewn with boulders, and some dangerous rocks exist near the channels; there are, also, extensive flats grown over with sea-grass.

*Barnstable Bay.*—Whether we regard its tides, its currents, its exposure to the sea, its anchorage, or the temperature of its waters, the character of Barnstable Bay appears to be quite at variance with that of Buzzard's Bay.

Of the tides I have already spoken, and I refer to them again only to state that, notwithstanding their great regularity and magnitude, their effects, as traceable in the currents, are inconstant and inconsiderable.

The currents of Buzzard's Bay pursue directions nearly parallel to the shores as they fill and drain the creeks and basins, while the natural course of those of Barnstable Bay would be normal to the shore-line, were it not that here a coastwise current exists, which is at some points much stronger than the tidal flow.

Table No. 5 furnishes the results from three stations in Barnstable Bay,—"No. 1, two miles northward of Peaked Cliff;" "No. 2, off Scusset," opposite the place of embouchure of the proposed canal; and "No. 3, off town of Sandwich." Diagram No. 4 shows the position of these stations.

At Station No. 1, the existence of a coast current was first discovered, This current pursued a northward course for about eleven hours out of the twelve, reaching a maximum velocity of about three-quarters of a mile per hour. It slacked up when the tide had risen to about one-third of its range, and for a little more than two hours after the surface-water

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remained nearly motionless, while the lowest water stratum indicated 0.20 miles of flood (southwesterly) drift.

I have made out Table No. 5 for the surface-current only, since marked variations for different depths were rarely traced. At one time it was perceived at Station No. 1, that the lower current, for two hours, took a direction more shoreward than the upper, and as a general thing the velocity of the former was somewhat in excess of hat of the latter. The aggregate of hourly velocities for this station is 6.60 miles, in a northwardly direction, which may be regarded as a powerful scouring force. At Station No. 2 we begin to lose the coast-current, and at No. 3 the maximum velocities of ebb and flood become equal, although the aggregate movements still show a north-westerly predominance. At these two stations the scouring powers are very feeble.

There is in Barnstable Bay no protection from storms, which usually blow directly on shore, and create a heavy sea calculated to trip a vessel's anchor, even if good holding-ground be found. Our three stations lay in $5\frac{1}{2}$, $6\frac{1}{2}$, and $4\frac{1}{2}$ fathoms, and at all we found hard bottom, quartzose sand. I was informed that vessels had found good, sticky anchorage in five fathoms water along this coast, but I did not observe this kind of bottom in less than seven fathoms. The heavy anchor of a ship might, perhaps, penetrate to a muddy stratum underlying the sand, but our own anchor, weighing about four hundred pounds, took but slight hold.

*Temperatures.*—Table No. 6 and Diagram No. 5 offer a comparison of temperatures of air and water for the termini of the proposed canal for each day, from July 31st to August 16th, inclusive. The general results of these comparisons are as follows: Back River Harbor, for the period of our observations, maintained a very great uniformity of temperature, its mean exceeding that of the air in the shade during the day about three degrees, and during the night about six degrees. Under the direct rays of the sun this quiet basin accumulated heat to such a degree that even in the night its temperature was once obsreved at seventy-eight degrees, and its mean night temperature for our series was seventy-three degrees.

Barnstable Bay, traversed by a coast-current which constantly replaces the heated water of the shores by new supplies from the ocean, maintains a comparatively low temperature, its mean for our series being fifty-four degrees, or nineteen degrees below the mean of Back River Harbor. The lowest temperature observed on the Barnstable Bay side was forty-eight degrees; the highest, sixty-three degrees. Our table shows a greater fluctuation of temperatures in this basin than in Back River Harbor; and this is no doubt due to the nature of the observations, which were made at the tide-gauge—a point so near the shore that

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the coast-current does not always sweep by it, and at best is sluggish in this shallow water. It cannot be attributed to any difference of specific heat in the waters of the two basins, for they do not differ much in their saline qualities, and the difference of specific gravity was found to be for Back River Harbor, but six-thousandths less than that of ocean water. Our mean, fifty-four degrees, is probably a little in excess of the temperature of the axis of the coast-current I have referred to.

The mean annual temperature of the air at Nantucket is fifty degrees, (see Smithsonian Reports,) or but four degrees less than our results for the water of Cape Cod Bay in the warmest month of the year. It would be a highly interesting inquiry to ascertain if the winter temperature of this bay, in the absence of ice, differs no more from the annual mean, and whether ice actually forms here or is only crowded in by the winds. Captain Pelham Gibbs, a very excellent and intelligent resident of Scusset, writes, in reply to my inquiries on this matter, "Barnstable Bay cannot be said ever to freeze, that is, so as to form a field of ice—at least it has not within my memory—but Buzzard's Bay closes nearly every winter as low down as Bird Island Light." Captain Gibbs further remarks, that "the ice which is sometimes seen in Barnstable Bay is a sort of slurry (porridge?) which is driven to the southward and lodges on Brewster Flats. If further investigation should show that this coast stream retains in winter the ocean temperature, it may prove a very great advantage to allow a circulation through the proposed artificial harbor, and thus prevent its freezing. When we consider that of all bodies water parts with its heat most reluctantly, it may be even possible to prevent the freezing of the canal by allowing a stream to flow to the westward through it at times of severe cold. Nantucket Sound, traversed by streams from the ocean, rarely freezes in winter, although its variations of temperature follow those of the air to a great degree. I observed, in the year 1855, that the temperature of the surface current rose as high as seventy degrees during the month of August.

*Action of Waves.*—The action of the waves on the shore of Barnstable Bay is much less than that upon the outside coast. The sea is very tranquil in all winds which blow off shore from south-east round to west, there being at such times little or no breaker upon the beach. It is with winds from north round to east that the greatest action is observed. At such times the sea gradually becomes lashed into great fury, and the beach is much torn by the breakers. The waves drive on diagonally, rolling the shingle along shore to south-east, and cutting away the sand from one point to heap it higher up at another. We traced the effects of several easterly storms of no great violence, by previously depositing in lines, bricks and articles of pottery. These remained almost motionless on the shore while westerly winds prevailed, but were removed by

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the waves during the storms; the larger portion being buried in the sands near high-water line, but others borne along to the south-eastward, distances varying from fifty to twelve hundred feet in the course of twenty-four hours. On one occasion some saucers of earthern ware were wholly buried by one storm, and no trace of them could be found until a succeeding storm washed one of them out at the distance of twenty-one hundred feet from the place of first deposit. It was observed that heavy articles, placed near the low-water line, travelled along to the eastward in courses nearly parallel to the shore line; while light and floating articles were soon cast high up on the beach.

Diagram No. 6 exhibits upon profile paper the results of two sets of levellings, one before, the other after an easterly storm. These levellings, setting out from the in-shore tide-gauge, ran in a straight line to a boulder near mean-water line; then, slightly deflecting, pursued again a straight line, lying in a similar position to the first as to the shore line. The length of the lines upon the diagram are 4,400 feet, and the elevations were determined for every ten feet. As the shore line has various curves, our line of levels runs over a variety of slopes, at some points passing along the high-water ridge. I have drawn the mean high and low-water lines on the diagram, to show the relative position of our points to the sea at different stages of the tide. It will be seen that this storm affected the beach at an elevation of about four feet above mean high-water, or about three feet above high-water of spring tides, but that the violent action was not confined to any special height within the reach of the sea. The changes of elevation are, at most, not above two feet at any point. Several other lines were run, to observe the effects of other storms, but the changes, as a general thing, were too small to be noticed here.

The general conclusion is, that ordinary storms are not violent in their action on this beach. I ought, however, to mention that Captain Gibbs informs me that changes of elevation of ten feet have been noticed after gales of very great violence.

Trusting that the results of my labors, as above described, may meet your approval,

I remain, very respectfully, yours,

HENRY MITCHELL, *Assistant Coast Survey.*

To Prof. A. D. BACHE, *Sup't. Coast Survey, &c. &c.*

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No. 1.—*Tides at termini of Proposed Cape Cod Canal—Results from Observations of July and August*, 1860.

| | Back River Harbor. | | Barnstable Bay. | |
|---|---|---|---|---|
| | | Referred to Local Bench. | | Referred to Local Bench. |
| | h. m. | | h. m. | |
| Corrected establishment of high water, | 7.52 | – | 11.15 | – |
| Corrected establishment of low water, | 13.15 | – | 17.26 | – |
| Mean height of high water above mean sea level, | ft. dec. 2.05 | ft. dec. —0.65 | ft. dec. 4.59 | ft. dec. —19.34 |
| Mean fall of low water below mean sea level, | 2.06 | —4.76 | 4.58 | —28.51 |
| Mean rise and fall, | 4.11 | – | 9.17 | – |
| | h. m. | | h. m. | |
| Duration of rise, | 7.01 | – | 6.14 | – |
| Duration of fall, | 5.23 | – | 6.11 | – |
| Duration of high water stand, | .27 | – | .21 | – |
| Duration of low water stand, | .26 | – | .18 | – |
| | ft. dec. | | ft. dec. | |
| Rise and fall of springs, | 4.69 | – | 10.58 | – |
| Rise and fall of neaps, | 3.19 | – | 8.03 | – |
| Greatest rise observed above mean sea level, | 3.37 | +0.67 | 6.47 | —17.46 |
| Greatest fall observed below mean sea level, | 3.33 | —6.03 | 6.46 | —30.39 |

*Positions of Gauges and Benches.*—At Back River Harbor the gauge was placed directly in front of Capt. Cahoon's house, distance 168 feet. The bench is a circle cut on highest point of a boulder. The centre of this circle is the place of reference. The letters "C. S." are carved in the stone. This boulder is situated about 309 feet distant in an easterly direction from place of gauge.

At Barnstable Bay the gauges were placed about one-quarter of a mile northward of Swift's house (see top. sheet.) The bench boulder is situated about 707 feet from Swift's house on a line running 8° to right of Peaked Cliff triangulation point; it is marked in same manner as that at Back River Harbor, above described.



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No. 2.—*Maximum Variations of the Relative Heights of Barnstable and Buzzard's Bays, from Observations of* 1860.

| DATE. | Time. | Moon's Transit. | Barnstable Bay above Back River Harbor. | | Back River Harbor above Barnstable Bay. | | Wind. | |
|---|---|---|---|---|---|---|---|---|
| | | | Interval. | Height. | Interval. | Height. | Direction. | Force. |
| **1860.** | h. m. | h. m. | h. m. | ft. dec. | h. m. | ft. dec. | | |
| July 21, | 14.09 | 2.19 | 11.50 | 6.75 | – | – | S. W. | 3 |
| | 20.20 | 14.55 | – | – | 18.01 | 5.63 | W. | 2 |
| July 22, | 2.25 | 3.20 | 11.30 | 7.75 | – | – | N. W. | 1 |
| | 8.45 | – | – | – | 17.50 | 6.15 | N. N. W. | 3 |
| | 15.00 | 15.45 | 11.40 | 6.60 | – | – | W. S. W. | 2 |
| July 23, | 3.16 | 4.10 | 11.31 | 7.21 | – | – | W. | 1 |
| | 9.30 | – | – | – | 17.45 | 5.98 | S. S. W. | 2 |
| | 15.45 | 16.35 | 11.35 | 6.00 | – | – | S. W. | 2 |
| | 22.15 | – | – | – | 18.05 | 5.00 | N. W. | 2 |
| July 24, | 3.53 | 5.00 | 11.18 | 6.95 | – | – | W. | 1 |
| | 16.55 | 17.26 | 11.55 | 6.00 | – | – | S. W. | 2 |
| July 25, | 5.03 | 5.52 | 11.37 | 6.10 | – | – | W. | 1 |
| | 17.30 | 18.18 | 11.38 | 6.11 | – | – | S. W. | 1 |
| July 26, | 6.00 | 6.46 | 11.42 | 5.85 | – | – | W. | 1 |
| | 18.36 | 19.03 | 11.50 | 5.65 | – | – | S. W. | 2 |
| July 27, | 1.30 | – | – | – | 18.44 | 4.83 | W. | 1 |
| | 7.25 | 7.41 | 12.22 | 5.60 | – | – | W. | 1 |
| | 13.38 | – | – | – | 18.35 | 4.08 | N. N. E. | 3 |
| | 20.00 | 20.10 | 12.19 | 6.00 | – | – | Calm. | – |
| July 28, | 2.20 | – | – | – | 18.39 | 4.40 | N. N. E. | 1 |
| | 8.23 | 8.38 | 12.13 | 4.85 | – | – | N. E. | 1 |
| | 14.00 | – | – | – | 17.50 | 4.23 | E. | 1 |
| | 20.50 | 21.06 | 12.12 | 5.90 | – | – | S. W. | 1 |
| July 29, | 3.26 | – | – | – | 18.48 | 5.10 | W. | 1 |
| | 9.16 | 9.34 | 12.10 | 5.00 | – | – | S. W. | 1 |
| | 15.45 | 22.01 | – | – | 18.39 | 4.33 | S. E. | 3 |
| July 30, | 10.28 | 10.27 | 12.27 | 5.55 | – | – | N. E. | 1 |
| | 16.43 | – | – | – | 18.42 | 4.13 | S. E. | 1 |
| | 22.54 | 22.53 | 12.27 | 5.85 | – | – | W. | 1 |

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No. 2.—Continued.

| DATE. | Time. | Moon's Transit. | Barnstable Bay above Back River Harbor. | | Back River Harbor above Barnstable Bay. | | Wind. | |
|---|---|---|---|---|---|---|---|---|
| | | | Interval. | Height. | Interval. | Height. | Direction. | Force. |
| **1860.** | h. m. | h. m. | h. m. | ft. dec. | h. m. | ft. dec. | | |
| July 31, | 5.20 | – | – | – | 18.53 | 5.14 | S. E. | 1 |
| | 11.00 | 11.18 | 12.07 | 5.75 | – | – | S. E. | 1 |
| | 17.20 | – | – | – | 18.27 | 4.97 | S. | 3 |
| | 23.20 | 23.42 | 12.02 | 6.50 | – | – | Calm. | – |
| Aug. 1, | 5.46 | – | – | – | 18.28 | 5.18 | N. | 3 |
| | 12.00 | 12.05 | 12.18 | 5.95 | – | – | N. E. | 4 |
| | 18.04 | – | – | – | 18.22 | 5.33 | S. W. | 1 |
| Aug. 2, | 0.05 | 0.27 | 12.00 | 6.45 | – | – | N. | 2 |
| | 6.50 | – | – | – | 18.45 | 5.73 | E. | 1 |
| | 12.33 | 12.49 | 12.06 | 6.15 | – | – | E. | 1 |
| | 18.50 | – | – | – | 18.23 | 4.93 | E. | 1 |
| Aug. 3, | 0.55 | 1.10 | 12.06 | 6.50 | – | – | W. | 1 |
| | 7.24 | – | – | – | 18.35 | 5.53 | W. | 1 |
| | 13.18 | 13.30 | 12.08 | 5.90 | – | – | W. S. W. | 3 |
| | 19.37 | – | – | – | 18.27 | 5.03 | – | – |
| Aug. 4, | 1.33 | 1.50 | 12.03 | 6.25 | – | – | S. W. | 2 |
| | 7.55 | – | – | – | 18.25 | 5.73 | S. W. | 3 |
| | 13.55 | 14.10 | 12.05 | 5.35 | – | – | W. | 4 |
| | 20.00 | – | – | – | 18.10 | 4.64 | W. S. W. | 3 |
| Aug. 5, | 2.30 | 2.30 | 12.20 | 5.90 | – | – | W. | 1 |
| | 8.34 | – | – | – | 18.24 | 4.82 | N. W. | 2 |
| | 14.25 | 14.49 | 11.55 | 5.65 | – | – | N. E. | 2 |
| | 20.24 | – | – | – | 17.54 | 4.53 | Calm. | – |
| Aug. 6, | 2.43 | 3.09 | 11.54 | 6.20 | – | – | W. N. W. | 2 |
| | 9.16 | – | – | – | 18.27 | 4.43 | N. E. | 2 |
| | 15.10 | 15.29 | 12.01 | 5.85 | – | – | N. E. | 2 |
| | 21.00 | – | – | – | 17.51 | 4.08 | S. W. | 1 |
| Aug. 7, | 3.20 | 3.50 | 11.51 | 5.65 | – | – | W. | 1 |
| | 9.30 | – | – | – | 18.01 | 4.40 | N. W. | 2 |
| | 15.50 | 16.11 | 12.00 | 5.15 | – | – | W. | 3 |
| | 21.44 | – | – | – | 17.54 | 3.98 | S. W. | 3 |
| Aug. 8, | 4.02 | 4.33 | 11.51 | 4.95 | – | – | W. | 3 |
| | 10.21 | – | – | – | 18.10 | 4.13 | W. S. W. | 3 |
| | 16.23 | 16.55 | 11.50 | 4.95 | – | – | W. | 4 |
| | 22.16 | – | – | – | 17.43 | 3.58 | W. | 2 |

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No. 2.—Concluded.

| DATE. | Time. | Moon's Transit. | Barnstable Bay above Back River Harbor. | | Back River Harbor above Barnstable Bay. | | Wind. | |
|---|---|---|---|---|---|---|---|---|
| | | | Interval. | Height. | Interval. | Height. | Direction. | Force. |
| **1860.** | h. m. | h. m. | h. m. | ft. dec. | h. m. | ft. dec. | | |
| Aug. 9, | 4.35 | 5.18 | 11.40 | 4.55 | – | – | S. W. | 3 |
| | 10.50 | – | – | – | 17.55 | 3.58 | S. W. | 3 |
| | 17.00 | 17.42 | 11.42 | 5.00 | – | – | S. W. | 3 |
| | 23.34 | – | – | – | 18.16 | 3.48 | S. W. | 2 |
| Aug. 10, | 5.50 | 6.07 | 12.08 | 4.35 | – | – | S. E. | 2 |
| | 11.30 | – | – | – | 17.48 | 3.20 | N. E. | 1 |
| | 17.40 | 18.33 | 11.33 | 4.70 | – | – | S. W. | 1 |
| Aug. 11, | 0.00 | – | – | – | 17.53 | 3.50 | N. | 1 |
| | 6.20 | 7.01 | 11.47 | 4.15 | – | – | N. | 1 |
| | 12.30 | – | – | – | 17.57 | 2.66 | N. N. E. | 3 |
| | 18.20 | 19.29 | 11.19 | 4.65 | – | – | N. E. | 3 |
| Aug. 12, | 1.20 | – | – | – | 18.19 | 3.78 | N. | 1 |
| | 7.20 | 7.57 | 11.51 | 3.91 | – | – | N. | 1 |
| | 13.30 | – | – | – | 18.01 | 3.43 | N. E. | 1 |
| | 19.40 | 20.27 | 11.43 | 4.86 | – | – | S. E. | 2 |
| Aug. 13, | 2.20 | – | – | – | 18.23 | 4.03 | S. E. | 2 |
| | 8.10 | 8.56 | 11.43 | 4.55 | – | – | S. E. | 2 |
| | 14.20 | – | – | – | 17.53 | 4.23 | S. S. W. | 4 |
| | 21.10 | 21.26 | 12.14 | 5.40 | – | – | S. S. W. | 4 |
| Aug. 14, | 3.22 | – | – | – | 18.26 | 4.93 | S. S. W. | 4 |
| | 9.35 | 9.56 | 12.09 | 5.15 | – | – | S. W. | 2 |
| | 15.40 | – | – | – | 18.14 | 4.78 | S. W. | 2 |
| | 21.30 | 22.25 | 11.34 | 6.60 | – | – | S. W. | 1 |
| Aug. 15, | 4.25 | – | – | – | 18.29 | 5.48 | N. | 2 |
| | 10.33 | 10.54 | 12.08 | 6.40 | – | – | N. | 2 |
| | 16.45 | – | – | – | 18.20 | 5.56 | Calm. | – |
| | 22.42 | 23.22 | 11.48 | 7.50 | – | – | N. N. W. | 2 |
| | 5.20 | – | – | – | 18.26 | 6.13 | N. | 1 |
| | 11.24 | 11.50 | 12.02 | 6.78 | – | – | N. E. | 1 |
| | 17.30 | – | – | – | 18.08 | 6.18 | Calm. | – |
| | 23.30 | – | 11.40 | 7.80 | – | – | W. | 1 |
| | Means, | – | 11.55 | 5.79 | 18.16 | 4.66 | – | – |

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No. 3.—*Daily Variations of the Mean Sea Level, or Alterations of the Half-tide Planes of each day, from General Mean.*

| DATE. | Back River Harbor. | Barnstable Bay. | Wind. | |
|---|---|---|---|---|
| | | | Direction. | Force. |
| **1860.** | | | | |
| July 18, | – | —.05 | Westerly. | 1 |
| 19, | – | —.14 | Southerly. | 2 |
| 20, | – | —.06 | S. W. | 1 |
| 21, | +.46 | +.25 | W. | 2 |
| 22, | +.18 | .00 | Westerly. | 3 |
| 23, | +.48 | +.18 | S. W. | 2 |
| 24, | +.32 | .00 | N. E. | 3 |
| 25, | +.12 | —.12 | S.Westerly. | 1 |
| 26, | —.05 | —.21 | S.Westerly. | 1 |
| 27, | —.15 | +.00 | N. E. | 3 |
| 28, | —.29 | —.15 | Easterly. | 3 |
| 29, | —.02 | —.17 | S. E. | 3 |
| 30, | +.22 | +.05 | S. E. | 1 |
| 31, | +.23 | +.20 | S. W. | 1 |
| Aug. 1, | +.02 | —.09 | Northerly. | 2 |
| 2, | —.18 | —.10 | – | 0 |
| 3, | —.19 | —.17 | W. | 1 |
| 4, | —.19 | —.20 | S. W. | 2 |
| 5, | —.30 | —.03 | N. N. E. | 1 |
| 6, | —.23 | +.16 | – | 0 |
| 7, | +.18 | +.18 | S. W. | 2 |
| 8, | +.17 | +.30 | S. W. | 3 |
| 9, | +.31 | +.19 | S. W. | 2 |
| 10, | .00 | +.15 | Southerly. | 1 |
| 11, | .00 | +.16 | Easterly. | 1 |
| 12, | —.43 | —.10 | – | – |
| 13, | —.05 | —.02 | S. E. | 3 |
| 14, | —.04 | —.03 | S. W. | 4 |
| 15, | —.14 | —.08 | N. W. | 2 |
| 16, | —.11 | —.11 | N. E. | 1 |
| 17, | +.12 | – | – | – |

REMARKS.—Mean level of Back River Harbor from 28 days' observations, was found to be 2.70 feet below the local bench. Mean level of Barnstable Bay for the same period was found to be 23.93 feet below local bench.

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No. 4.—*Half-Monthly Inequalities in Intervals and Heights, for Buzzard's and Barnstable Bays, from Observations of July and August*, 1860.

| MOON'S HOUR. | Back River Harbor. | | | | Barnstable Bay. | | | |
|---|---|---|---|---|---|---|---|---|
| | Lunı-Tidal Interval of High Water. | Height of High Water. | Lunı-Tidal Interval of Low Water. | Height of Low Water. | Lunı-Tidal Interval of High Water. | Height of High Water. | Lunı-Tidal Interval of Low Water. | Height of Low Water. |
| | h. m. | ft. dec. | h. m. | ft. dec. | h. m. | ft. dec. | h. m. | ft. dec. |
| 0.30 | 7.56 | 2.17 | 13.08 | — 2.30 | 11.11 | 5.04 | 17.22 | — 5.36 |
| 1.30 | 7.46 | 2.32 | 12.57 | — 2.33 | 11.06 | 5.11 | 17.16 | — 5.34 |
| 2.30 | 7.51 | 2.25 | 12.58 | — 2.44 | 11.03 | 5.12 | 17.12 | — 5.46 |
| 3.30 | 7.56 | 2.13 | 12.45 | — 2.02 | 11.01 | 4.81 | 17.06 | — 4.61 |
| 4.30 | 7.53 | 2.30 | 12.52 | — 1.74 | 10.59 | 4.78 | 17.15 | — 4.40 |
| 5.30 | 8.01 | 1.94 | 12.51 | — 1.75 | 11.08 | 4.22 | 17.18 | — 4.27 |
| 6.30 | 7.46 | 1.71 | 13.41 | — 1.48 | 11.10 | 4.07 | 17.26 | — 3.96 |
| 7.30 | 7.54 | 1.38 | 13.28 | — 1.98 | 11.24 | 4.01 | 17.36 | — 4.22 |
| 8.30 | 7.52 | 1.62 | 14.02 | — 1.97 | 11.22 | 4.14 | 17.40 | — 4.46 |
| 9.30 | 7.48 | 2.04 | 13.48 | — 2.05 | 11.30 | 4.36 | 17.32 | — 4.17 |
| 10.30 | 7.54 | 2.28 | 13.26 | — 2.26 | 11.37 | 4.73 | 17.45 | — 4.44 |
| 11.30 | 7.50 | 2.43 | 13.09 | — 2.45 | 11.35 | 4.66 | 17.48 | — 4.28 |
| Means, | 7.52 | 2.05 | 13.15 | — 2.06 | 11.15 | 4.59 | 17.26 | — 4.58 |

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No. 5.—*Currents of Buzzard's and Barnstable Bays, near Outlets of Proposed Canal. (To accompany Report to Prof. A. D. Bache, Supt. U. S. C. S., by Henry Mitchell, Assistant.)*

| Station. | LOCALITY. | Date. | Intervals. | | | | Duration of Slack Water. | | Durations of Currents. | | Maximum Velocities. | | Aggregates of Hourly Velocities. | | | | Depth at Low Water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | After Tide. | | After Moon's Transit. | | F. to E. | E. to F. | Ebb. | Flood. | Ebb. | Flood. | Ebb. | | Flood. | | |
| | | | F. to E. | E. to F. | F. to E. | E. to F. | | | | | | | Amount. | Central Direct'n. | Amount. | Central Direct'n. | |
| | *Buzzard's Bay.* | **1860.** | h. m. | h. m, | h. m. | h. m. | h. m. | h. m. | h. m. | h. m. | Miles per hour. | Miles per hour. | Miles per hour. | | Miles per hour. | | feet. |
| 1 | Off Pocasset, . | July 18, | 7.01 | 13.41 | – | – | § | § | 6.40 | 5.40 | .25 | 0.05 | 1.25 | S.W'ly | .21 | N.E'ly. | 13 |
| 2 | Bet. Meshnee I'd & Bennett's N'k, | 14, | 8.53 | 14.01 | – | – | .35 | .39 | 5.08 | 7.12 | .40 | 0.22 | 2.45 | S.W'ly | .23 | N.E'ly. | 15½ |
| 3 | W'd of Stony Pt., | 15, | 8.33 | 12.11 | – | – | .27 | .28 | 3.38 | 8.42 | .20 | .20 | .40 | S'ly. | 1.12 | N'ly. | 16 |
| 4 | Mouth of Back River Harbor, | 16, | 9.48 | – | – | – | § | § | § | § | .18 | .12 | 1.05 | S.E'ly. | .98 | N.E'ly. | 9⅓ |
| | *Barnstable Bay.* | | | | | | | | | | | | | | | | |
| 1 | Two miles N'ly of Peaked Cliff,* | 22 & 23, | —3.09 | 1.49 | 6.43 | 17.44 | 2.20 | .27 | 11.01 | 1.20 | .70 | Feeble. | 6.60 | N. by W. | .05 | S'ly. | 33 |
| 2 | Off Scusset,† . | 24, | — .22 | 1.30 | 10.00 | 18.10 | .10 | 2.00 | 8.10 | 4.10 | .20 | .10 | 1.10 | N. W. | .30 | S. | 39 |
| 3 | Off Sandwich,‡ . | 25, | —2.00 | .28 | 8.44 | 17.45 | § | § | 9.01 | 3.20 | .15 | .15 | 1.06 | N. W'ly. | .65 | N. E. | 27 |

* Hard bottom. † Fine sand. ‡ Hard sandy bottom. § Uncertain.

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No. 6.—*Comparative Temperatures of Buzzard's and Barnstable Bays, from Observations at termini of Proposed Cape Cod Canal.*

| DATE. | Wind. | | Mean Day Temperature. | | | | Difference. | | Mean Night Temperature. | | | | Difference. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Back River Harbor. | | Barnstable Bay. | | | | Back River Harbor. | | Barnstable Bay. | | | |
| | Direction. | Force. | Air. | Water. | Air. | Water. | Air. | Water. | Air. | Water. | Air. | Water. | Air. | Water. |
| **1860.** | | | | | | | | | | | | | | |
| July 31, | S. W. | 1 | 79 | 75 | 78 | 63 | — 1 | —12 | 68 | 70 | 67 | 57 | — 1 | —13 |
| Aug. 1, | Northerly. | 2 | 63 | 72 | 61 | 55 | — 2 | —17 | 65 | 74 | 55 | 55 | —10 | —19 |
| 2, | Calm. | – | 71 | 72 | 63 | 62 | — 8 | —10 | 54 | 71 | 54 | 60 | + 0 | —11 |
| 3, | W. | 1 | 73 | 74 | 66 | 60 | — 7 | —14 | 63 | 71 | 58 | 52 | — 5 | —19 |
| 4, | S. W. | 2 | 72 | 72 | 69 | 54 | — 3 | —18 | 68 | 72 | 68 | 47 | 0 | —25 |
| 5, | N. N. E. | 1 | 76 | 73 | 68 | 55 | — 8 | —18 | 67 | 72 | * | * | – | – |
| 6, | Calm. | – | 75 | 77 | 65 | 63 | —10 | —14 | 61 | 72 | 61 | 56 | 0 | —16 |
| 7, | S. W. | 2 | 73 | 76 | 72 | 56 | — 1 | —20 | 69 | 73 | 58 | 59 | —11 | —14 |
| 8, | S. W. | 3 | 73 | 75 | 78 | 52 | + 5 | —23 | 70 | 73 | 68 | 50 | — 2 | —23 |
| 9, | S. W. | 2 | 72 | 73 | 68 | 47 | — 4 | —26 | 71 | 73 | 68 | 48 | — 3 | —25 |
| 10, | Southerly. | 1 | 73 | 75 | 82 | 51 | + 9 | —24 | 70 | 71 | 65 | 48 | — 5 | —23 |
| 11, | Easterly. | 1 | 70 | 75 | 70 | 52 | 0 | —23 | 74 | 75 | 70 | 50 | — 4 | —25 |
| *12, | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 13, | S. E. | 3 | 78 | 78 | 74 | 54 | — 4 | —24 | 78 | 78 | * | * | – | – |
| 14, | S. W. | 4 | 75 | 79 | 71 | 56 | — 4 | —23 | 72 | 76 | 70 | 51 | — 2 | —25 |
| 15, | N. W. | 2 | 65 | 76 | 65 | 60 | — 0 | —16 | 62 | 75 | * | * | – | – |
| 16, | N. E. | 1 | 62 | 74 | 62 | 58 | 0 | —16 | 62 | 74 | 62 | 59 | 0 | —15 |
| Means, . | – | – | 72 | 75 | 70 | 56 | — 2 | —19 | 67 | 73 | 63 | 54 | — 4 | —19 |

* No Observations.

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# [VI.]

## SECOND REPORT.

*To the Superintendent of the U. S. Coast Survey, upon examinations of the approaches to the Proposed Cape Cod Canal, by* HENRY MITCHELL, *Assistant U. S. C. S.*

MELROSE, Mass., February 9, 1862.

DEAR SIR,—Since transmitting my First Report upon the examinations in the neighborhood of the Proposed Cape Cod Canal, I have, in obedience to your instructions issued at the request of the legislative committee, made some additional investigations bearing upon the question whether the proposed canal could be kept free from ice during the winter. This question, which is perhaps the most important one presented in the project, could not be solved by reference to the experience in similar constructions elsewhere, because the physical conditions were in this case found peculiar, and without parallel.

In my previous Report, I endeavored to state some of the leading phenomena attending the tides, currents and waves, at the termini of the proposed canal, and called your attention to a *cropping out* of a substratum of the sea in Barnstable Bay, which seemed to me to offer a favorable solution of the ice question, as far as the artificial harbor and the eastern entrance of the canal are concerned.

During the summer of 1861, while engaged upon hydrography in this section, I found opportunities for making observations of currents and temperatures in Cape Cod Bay. I ascertained that the "*cropping out*" in Barnstable Bay is of limited extent, and that the surface temperature which we had observed there corresponds with that obtained from considerable depths, at stations but a few miles distant. I select from my observations the following, as illustrative of this fact, remarking that the variations in the densities of sea water with changes of temperature have never been determined, that I am aware of, so that I am unable to compute the thermal conditions for different depths in the sea. It is known, however, that the maximum density is reached at a temperature considerably above twenty-seven degrees, the freezing point; and, taking into consideration the very feeble conducting power of fluids in general, we might expect that at an inconsiderable depth we should find, in midwinter, a uniform temperature.



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If the process of *circulation* does not go on into Barnstable Bay with the change of season, the lower-water stratum may preserve quite a high temperature through the winter. In the brackish waters of the Lower Mystic Pond, where the rapid increase of specific gravity with the depth precludes *circulation*, I found the mid-winter temperature, at ten fathoms, to be forty-five degrees.

*July*, 1861.

| Off Race Point. | | | Off Mary Ann Rocks. | | | Off Barnstable Light. | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth. | Temperature. | Specific Gravity. 60° | Depth. | Temperature. | Specific Gravity. 60° | Depth. | Temperature. | Specific Gravity. 60° | |
| 1 | 60° | 1.0243 | 1 | 62° | 1.02375 | – | – | – | Last of ebb. |
| 108 | 46° | 1.0251 | 96 | 50° | 1.0244 | – | – | – | |
| 1 | 58½° | 1.0244 | 1 | 63° | 1.0245 | 1 | 61° | 1.0241 | Last of flood. |
| 180 | 47° | 1.0251 | 96 | 55° | 1.0245 | 24 | 55° | – | |
| – | – | – | – | – | – | 40 | 50° | – | |

The temperature of the sea alters but little from day to day during the month of July, but there is a regular change between the ebb and flood currents. Our observations were usually made at different stations on consecutive days, taking care to work at corresponding tidal periods.

The surface temperature on the outside coast of Cape Cod, along the twelve-fathom line, I found to be uniform at sixty-one degrees, except in a certain region off Nausett, where a *cropping out* of cold water (fifty-one degrees) was found. I assume sixty-one degrees, then, to be the normal temperature of the surface of the sea in this section for the month of July.

It appears, from the observations off Race Point, that there is an increase of density with the depth, which, although very small, is quite distinctly measured both upon the ebb and flood. It is reasonable to suppose that this variation is due to the presence of fresh water from land streams, since the density at depth of one hundred and sixty-eight feet corresponds with that usually assumed to represent sea water, while the upper stratum is specifically lighter. I attach some importance to these facts, because they are intimately connected with the theory of vertical circulation.

If, as would appear, the water of Barnstable Bay is supplied continually from a lower stratum of the sea, the question arises, *is its temperature kept at all times above the freezing point in winter?*

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The freezing point of the Barnstable Bay water I have very carefully determined to be 28¼ degrees. I obtained a specimen of this water during very cold weather, when the land streams were all frozen; its specific gravity was 1.026. By exposing it in a glass jar for eleven hours, to an atmospheric temperature of ten to twenty-two degrees, I succeeded in converting about one-third of the specimen into a spongy case of ice. The residuum water I found to have a temperature of 26½ degrees; the density (at forty degrees) was 1.037. On melting the ice, I obtained water with a density of 1.007.

The salt, precipitated in the freezing process, so impregnates the water below and in the cells of the ice, that its freezing point is lowered—perhaps the cellular or spongy character of sea-water ice is itself an effect of the concentration of the salts. When the ocean freezes, may it not be possible that water directly below the ice becomes so impregnated with salt, and consequently so heavy, that it sinks, and thus carries down to considerable depths a low temperature?

The freezing point of Buzzard's Bay and Boston Harbor waters is twenty-nine degrees.

The winter of 1860–61 was one of unusual severity; Boston Harbor became very much encumbered with ice, but *none was seen in Barnstable Bay.* This winter (1862) the cold has been very steady, but not severe. On the 6th of February, after the coldest period thus far experienced this season, I visited Barnstable Bay, and found its temperature thirty-two degrees *for all depths* as far out as the six-fathom line; and, of course, not a vestige of ice. Boston Harbor, at this time, was closed except along the channel ways, where the currents are strong; and the upper portion of Buzzard's Bay was wholly frozen over.

The uniformity of temperature for different depths, given by the observations above referred to, might lead us to expect the formation of *bottom* or *anchor* ice, should the sea ever become but a trifle colder, so as to congeal fresh water springs (if there are any) welling from the bed of the bay.

My observations confirm me in the opinion that no trouble from ice will be experienced at the eastern terminus of the canal. If no fresh-water feeders are permitted, and a current of one mile per hour (average) be kept flowing in a westwardly direction during the alternate tidal periods of six hours, the canal may, I am confident, be kept free during the coldest winter day.

Very respectfully, yours,

HENRY MITCHELL, *Assistant U. S. C. S.*

Prof. A. D. BACHE, LL. D., *Superintendent U. S. Coast Survey.*

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## [VII.]

ENGINEER DEPARTMENT, WASHINGTON,
April 26, 1826.

TAPPAN WENTWORTH, Esq., Lowell, Mass.

DEAR SIR,—Your letter of the 22d inst. was not received till yesterday, and the report, mentioned therein, of the engineer appointed to superintend the survey of the Ship Canal to connect Barnstable and Buzzard's Bay, did not reach me till to-day.

My connection with the subject of that canal having been authorized by the late Secretary of War, I considered it proper to communicate to Mr. Stanton (now at the head of the War Department) the substance of your letter, and to report to him that any further consideration of the subject by me will be entirely incompatible with indispensable attention to my official duties,—and it is with his approval that I now so report to you.

These official duties are at this moment much in arrears, notwithstanding the devotion of every moment that I—with probably too great a strain upon my health and strength—am able to give.

The little service—if indeed it has been of any amount—that I have heretofore rendered, I have cheerfully afforded, but it is impossible for me to engage further in the matter, and it is proper for me to state this to you explicitly.

I accordingly return the report above mentioned of Mr. Baldwin, by this day's mail, to your address. I have not been able to look into it at all.

With great respect, your obedient servant,

JOS. G. TOTTEN.

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# [VIII.]

## REPORT

*Of the Engineer appointed by the Resolve of the Massachusetts Legislature to Superintend the Surveys for a Ship Canal to connect Barnstable Bay and Buzzard's Bay, under the authority of a Joint Committee appointed at the Legislative Session of* 1860–61. *Approved March* 14*th*, 1861.

To Gordon M. Fisk, Esq., *Chairman of the Joint Committee on Barnstable and Buzzard's Bay Ship Canal:*

Sir,—In obedience to the directions of your Committee last spring, I continued to direct the surveys for the ship canal which had been commenced, under the rule of the former committee, by Messrs. J. G. Chase and W. F. Durfee, engineers, appointed before I was engaged in the work; the latter gentleman, being a member of the legislature, was early called from the work, and the surveys were completed by the former, with the exception of some soundings in Buzzard's Bay for ascertaining the cost of dredging a channel from the terminus of the canal to deep water, which Mr. Durfee executed after the main surveys were completed. I have the pleasure to acknowledge the industry and exactness with which the work has been done. The accompanying large plan, made by Mr. Chase and assistants, upon a large scale, exhibits the results of these surveys, together with the details I have furnished of the locks, sluice, breakwaters, &c.

Besides our own surveys, we have been greatly aided by those made by the Coast Survey officers in 1860, in furtherance of the present investigations. These were both topographical and hydrographical. The latter, particularly, has been indispensable in fixing with sufficient definiteness the proper levels for the canal bottom, lock inverts and copings.

The tidal records and observations given in Mr. Mitchell's report, attached to that of General Totten's, to the legislative committee, has almost wholly formed the basis of our work in regard to the above mentioned particulars. It would have been desirable if these records had been prolonged into other more stormy months, or, better still, for an entire year, as they represented only the tidal phenomena for about one month; nevertheless, from them enough has been obtained to answer immediate purposes. As usual in all such investigations, a few observa-

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tions are accepted to start with, but before commencing operations further examinations are generally required. Under a few general heads I propose to explain the surveys and details of the works proposed, as represented on Mr. Chase's map, before mentioned.

### Tidal Observations.

But little has been done by us the last year in observing the tides in addition to what the Coast Survey of the previous year have furnished. A gauge was kept for some time, under Mr. Chase's direction, at Back River Harbor and at Monumet Bridge. The results from these were of little value, except ascertaining the height of an extraordinary high tide, called by the inhabitants of the locality the highest that had occurred since the great gale of September, 1815, which exceeded any thing ever before heard of in that vicinity. From the evidence of several citizens who reside near Monumet River, and who witnessed the last mentioned tide and pointed out to Mr. Chase the points to which it flowed, it has been ascertained, by levelling, that the water then rose to a level $65\frac{944}{1000}$ feet above the base line of Mr. Chase's surveys, this base line being $52\frac{694}{1000}$ feet below the mean level of the tidal ebb and flow in Buzzard's Bay, and consequently to the same height above that of Barnstable Bay, as the report of Mr. Mitchell shows, for he proves that the mean levels of the ebb and flow of the tide in each bay are in the same terrestrial plane, and corresponds to the mean level of the sea; a fact which has been found true in many other places on the globe. As the maximum tide of Mr. Chase's observations, alluded to above, was only $57\frac{837}{1000}$ above base, this great tide of 1815 rose $8\frac{107}{1000}$ feet higher than any tide for the last forty-six years. On the supposition that the mean of the rise and fall of the tides in all estuaries where there remains several feet of water in the channel out to sea at low tide agrees with the mean level of the sea, such a tide as that of 1815 would have risen $3\frac{650}{1000}$ feet above the coping of the navy yard dry dock, Charlestown, had it occurred in Boston Harbor, assuming the coping to be $9\frac{60}{100}$ feet above the mean level of the sea,—the assumption being based on what I find to be about the mean of three years' gaugings kept at the navy yard for my brother, L. Baldwin, in 1830, '31, '32, and the gaugings for year 1852 I obtained, through the kindness of Mr. Henry Mitchell, from the Coast Survey Department, in the form of a diagram.

In the event of another such tide as that of 1815 happening after the completion of the canal, as designed, the water would flow into the canal covering the lock at Back River Harbor to the depth of $3\frac{25}{100}$ feet. In anticipation of a repetition of a similar gale and tide, this lock should be secured against injury by pavements, and the western bank of the canal

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up the Monumet River raised for a barrier against any encroachment in that direction.

On Barnstable or Scusset side of the Cape the levels of two extraordinary tides that occurred at West Sandwich Mills, and pointed out to us by Mr. Keith, have been referred by levelling to the plane of reference. The highest took place in 1855, and was $65\frac{120}{1000}$ feet above base; the other, $64\frac{679}{1000}$ above, happened at the time Minot's Ledge Light-house was destroyed, in the year 1851. Both of these tides would rise above the level we have assumed for the Scusset lock coping; the first $2\frac{046}{1000}$ feet, the second $1\frac{605}{1000}$ feet above; and if no provision should be made to stop the water at one of the gates, it would flow into the canal and raise it some five or six inches, provided there existed no reservoir open to the trunk of the canal for it to expand in. It is believed it would not be necessary to raise the lock walls for these extraordinary tides, which do not appear to come round oftener than one in twelve or fifteen years; besides, it is still a question whether these same tides did rise to the same height out in the bay as they did at the mill situated at the head of a narrow and deep cove of the great Sagamore Marsh—a distance of 9,000 feet from the sea shore. The wind at the time probably blowing a gale, would tend to force the water into the mouth of the Scusset, and perhaps dashing it through the hollows of the dunes, thereby causing an accumulation of tide-water on the marsh up to the mills. The tide of 13th August, 1861, as marked by Mr. Keith near his mills, was $58\frac{840}{1000}$ above base. At the same time, Captain Pelham Gibbs, of Scusset Village, made marks along the beach, north of the Olive Swift House, and near the Coast Survey beach mark, of the height to which the sea-wruck was thrown by the waves during the gale that occurred on that day; this level of these marks was referred to the plane of reference, by levellings made by Mr. Durfee, and found to be $61\frac{297}{1000}$ above base, or $2\frac{457}{1000}$ feet higher than the mark made at Keith Mills. I observed the *sea-wruck* line corresponded precisely with the outer limit of the beach-grass, not only at the place where the marks were made, but at other places near the proposed site for the locks. This fact indicates that inside that line the waves seldom cause erosions of the sand.

For convenience of reference the following general table of levels is given, all referred to the same plane of reference used by Mr. Chase on his surveys and map:—

| | Above Base. Ft. Dec. |
|---|---|
| Mean level of the sea, as established by Mr. Henry Mitchell, of Coast Survey, . . . . . | 52.694 |
| Mean high-water in Barnstable Bay, off Scusset, observed July and August, 1860, . . . . . | 57.284 |
| Mean low-water in Barnstable Bay, off Scusset, observed July and August, 1860, . . . . . | 48.114 |

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| | Above Base. Ft. Dec. |
|---|---|
| Greatest rise of tide observed in Barnstable Bay, off Scusset, July and August, 1860, | 59.164 |
| Greatest fall of tide observed in Barnstable Bay, off Scusset, July and August, 1860, | 46.234 |
| High-water at extreme neap tides off Scusset, observed July and August, 1860, | 55.644 |
| Mean high-water at Back River Harbor, observed July and August, 1860, | 54.744 |
| Mean low-water at Back River Harbor, observed July and August, 1860, | 50.634 |
| Greatest rise of tide observed at Back River Harbor, July and August, 1860, | 56.064 |
| Greatest fall of tide observed at Back River Harbor, July and August, 1860, | 49.364 |
| Surface of Sagamore Marshes, about | 57.230 |
| Coast Survey bench mark on boulder near Scusset, | 76.624 |
| Surface of proposed canal, if fixed at four feet above mean level of the sea, | 56.694 |
| Coast Survey bench mark on boulder in Back River Harbor, | 55.394 |
| Marsh on sides of Monumet River, say | 55.300 |
| Great high tide of gale, September, 1855, in Buzzard's Bay, about | 65.944 |
| Highest tide in Buzzard's Bay since September, 1815, observed by Chase, March 9, 1861, | 57.837 |
| High tide at Keith's Mills, West Sandwich, in 1855, | 65.120 |
| High tide at Keith's Mills, West Sandwich, on day Minot's Ledge Light-house was destroyed, | 64.679 |
| High tide at Keith's Mills, West Sandwich, August 13th, 1861, | 58.840 |
| Level of sea-wruck, as left on Scusset Beach, August 13th, 1861, | 61.297 |
| Summit on Sagamore, surveyed line, | 58.287 |
| Summit on Scusset, surveyed line, (Difference—38.205) | 120.792 |
| Coping of Back River and Scusset Locks, as proposed, | 63.074 |
| Invert of Back River Lock, lowest part, as proposed, | 31.694 |
| Invert of Scusset Lock, lowest part, as proposed, | 29.694 |
| Bottom o canal at foot of side-slopes, | 38.694 |
| Bottom of canal in middle, if required to be deepened, | 36.694 |
| Bottom of sluice at Scusset, | 29.694 |
| Bottom of concrete foundation of Scusset Lock, as proposed, | 15.694 |
| Bottom of concrete foundation of Back River Lock, as proposed, | 18.694 |
| Coping of dry dock in Charlestown Navy Yard, assumed to be, | 62.294 |
| Mitre sill of dry dock in Charlestown Navy Yard, assumed to be, | 32.294 |
| Mean level of the sea at Charlestown Navy Yard, per L. Baldwin's gaugings, 1830, '31, '32, | 52.784 |
| Mean level of the sea at Charlestown Navy Yard, per Coast Survey diagram for 1852, | 52.594 |

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| | Above Base. Ft. Dec. |
|---|---|
| Mean high-water at Charlestown Navy Yard, per L. Baldwin's gaugings, 1830-1-2, | 57.594 |
| Mean low-water at Charlestown Navy Yard, per L. Baldwin's gaugings, 1830-1-2, | 47.599 |
| Maximum high-water at Charlestown Navy Yard, per L. Baldwin's gaugings, say | 62.624 |
| Maximum low-water at Charlestown Navy Yard, per L. Baldwin's gaugings, | 44.874 |

## The Examined Lines.

The southern terminus of the canal is located at Back River Harbor, where all the former surveys, with the exception of Mr. Hill's, have terminated; it is a small harbor and not deep enough for the navigation it is now proposed to accommodate; the previous projects being for much smaller vessels. Although the harbor in its natural state is too shallow and contracted, it can be deepened and enlarged at a moderate expense —Stony Point answering well for a breakwater to screen and cause still-water at the lock entrance, and when walled, as proposed, would furnish a long and convenient wharf for vessels to stop at in the course through the canal. The present channel out to deep water in Buzzard's Bay is now very direct, but the bottom is somewhat uneven, as seen by the soundings marked down on the plans; very little of it from the harbor to the northerly part of Wing's or Wenaumet Neck is deep enough, and should be dredged to a width of 600 feet, to allow a free passage for the large steamers that would be able to pass through the canal. For immediate purposes, on opening the canal, and to save outlay, the channel may be contracted to 300 feet in width, as supposed in the *reduced estimate* we give below.

Although there is water on the opposite side of Stony Point two or three feet deeper than in the harbor, it is open to the bay on the west, and considerable expense would be incurred on that side to protect the lock entrance. The channel outwards, thence to deep water, would be circuitous, or if made straight, probably much more expensive than the other from the harbor. The cost of cutting the canal on this route, would not, we think, be less than on the adopted line, and as no particular examination was made to settle the question of choice between the two lines, it would be advisable before commencing operations to cause it to be examined.

The line from Back River Harbor to the lower part of Monumet River, is the most favorable of any that could be drawn to enter the harbor, at least as to the cost; it passes across a low swamp, a salt water pond, and other low ground of considerable extent, which very considerably relieves the excavation, and makes the remainder of easy execu-



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tion, the deepest cutting on this division is $36\frac{40}{100}$ feet. The soil appears of easy removal, with few boulders to be expected under the surface.

After entering the Monumet, on a curve of 3,000 feet radius, the canal would occupy its left side for nearly 5,000 feet, then crossing to the right bank, passes across the Monumet Bridge road between the bridge and railroad depot, afterwards soon crosses the river again at the railroad viaduct; from thence it follows the general course of the river to the lower mill at North Sandwich. In executing this part of the work—considered of easy excavation—the bed of the river and the greater part of the bordering marshes would be obliterated, as far down as the place where it is proposed to carry the railroad across the canal, as shown on the map. Of course the canal would afterwards become the artificial channel for the drainage of the bordering lands and country, including Herring Brook.

The Cape Cod Railroad crosses this part of the line at a very acute angle, forbidding the adherence to its present location; it should cross at right angles over the canal; and, to avoid making inconveniently short curves, it is proposed to divert it from its present location at a point near the east end of the bridge, across the outlet of Buttermilk Bay; thence, by reversed curves, to cross the canal at right angles, near Berry Cove, near where the canal line from Back River Harbor enters the Monumet. After crossing the canal, the new location would curve towards the east into a straight line, directed to a point in the existing location of the railroad, 2,200 feet easterly of the viaduct above mentioned. The length of new road required for this change is about $2\frac{1}{4}$ miles, the cost of which, exclusive of draw-bridge across canal, it is judged would be about $12,000 per mile. As the ground on the route just described has not been surveyed, no particular estimate can be attempted. It is very probable the proprietors of the Cape Cod Railroad would acquiesce in this alteration, for it would very much facilitate a connection with the contemplated railroad from Monumet to Falmouth, notwithstanding the length of their road would be increased about 1,700 feet.

From North Sandwich lower mill the canal line soon passes across the railroad, and enters the swampy wood south-east of the village, emerging from it and passing over the railroad near the point where it is crossed by the county road leading from North to West Sandwich; thence the line continues along the lowest part of the valley on the summit between the two bays, a distance of about one thousand feet, to the point where Scusset and Sagamore lines diverge, and near the summit point of the latter line—each line afterwards passing to the shore of Barnstable Bay, independent of each other. The Sagamore branch soon traverses Keith's Mill Pond, around the southerly end of the Scusset hills, with a radius of 2,700 feet, and across the marsh to the

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beach near coast-survey station G, touching on the way across the marsh the westerly foot of Sagamore hill. The Scusset branch curves with a radius of 3,000 feet towards the north, and soon enters the deep cutting which extends about 3,000 feet through the cultivated field back of Scusset Church and Village, issuing at the deep ravine on the easterly side of the ridge, thence passing across some cultivated fields, and over 1,000 feet of the extreme northerly part of the great Sagamore Marsh, terminates at the beach, about 1,600 feet from the termination of the Sagamore line, and where the entrance lock and feeding sluice would be located. The lengths of the two lines, from the head of the lock at Back River Harbor to the head of its proper lock at Scusset beach are, for the

| | | |
|---|---|---|
| Sagamore Line, . . . . | 40,445.29 feet, or | $7\frac{66388}{100000}$ miles. |
| Scusset Line, . . . . | 38,394.47 feet, or | $7\frac{27168}{100000}$ " |
| Difference in the length of the lines, | 2,070.82 feet, or | $0\frac{38220}{100000}$ miles. |

The character of the soil on the Sagamore branch of the surveyed lines, from the point of divergence to some distance below Keith's Mills, resembles that passed over from the lower mill at North Sandwich to the same point, both traversing some swampy land, where cranberry yards have been made; but generally the ground indicates a sandy formation, with some gravel, and very few boulders. The point of Scusset Hill appears harder, and more covered with boulders.

The quality of the sub-soil on the Scusset or Deep-cut line has been pretty fully ascertained by numerous inquiries concerning what was found in digging several wells at Scusset Village, the positions of which are indicated on Mr. Chase's map. It results from the information obtained of the citizens there by Mr. Chase, that the upper stratum across this ridge is composed of gravel about three feet deep; then follows a stratum of gravel mixed with clay a further depth of six feet; below this all is pure sand, similar to that of the sea beach, down to the bottom of the wells for fifty or sixty feet, or nearly to level of high-water mark of the bay; no well has more than two to three feet water in it, and none ever become dry.

It is quite possible that this example of the geological formation of the vicinity of Scusset Village extends across the Cape from bay to bay, and that the gravel and in a few places massive and numerous boulders, seen along the routes surveyed, are superficial, and that the excavations, as they are carried down below the level of high-water mark, will be easily executed, if not quicksand, either by laying the work dry or by dredging, should the expense and difficulties of the former method be found insurmountable.

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Soundings have been made with the iron rod at several points along the surveyed lines. These points, and the depths to which the rod was forced, are all marked on the longitudinal profile of the survey given on the map. Those on the marsh and in the bed of Scusset River are interesting, as they show there exists a great uniformity in the depths from the surface of the marsh to a solid structure of sand of about twenty feet. One sounding, made in the bed of the river, through marshy mud, produced a powerful fresh-water spring, of artesian character, that soon dispelled some two or three feet of the salt water of the creek, and continued for a long time to boil up, and supplied the party with what they wished to drink. This fact is ominous, and indicates trouble in carrying down deep and open excavations in the neighborhood. Likewise the existence of a stratum of soft marsh, of twenty feet in thickness, is indicative of trouble, or of great expense in securing it against subsiding into the trunk of the canal when it is loaded with the necessary embankments for roads or towing paths. This last objection bears against the adoption of the Sagamore route, which passes a much greater distance over the marsh than the Scusset does, its hardness also being much less.

The interference with the railroad at North Sandwich makes it necessary to divert it at a point near the lower mill on the Monumet, and carry it, at a convenient grade, along the top of the southerly bank of the canal, above the tow-path, where a breadth of four rods may be appropriated to its use, until it enters the existing location, near the second road crossing from North Sandwich towards West Sandwich. The carriage road that now goes east from the mill towards West Sandwich, along the southerly side of the valley, must likewise be changed at several places, to give room for railroad, as indicated on the map. The cost of changing the railroad is included in the estimate.

At the head of both locks, where basins are required, the ground is favorable for their construction. At Back River the basin would be 1,500 feet long and 252 feet wide, including the body of the canal, at top-water line. At Scusset, the basin on the Scusset or Deep-cut, as shown on the map, would be 1,000 feet long and 500 feet wide, including body of the canal, extending entirely across the marsh, from the beach to the upland. That on the Sagamore would have a length of 1,300 feet, and breadth of 500 feet; extending from the beach into the marsh, and occupy portions of Bass River and Beach Creek. The cost of making these two latter basins we have supposed, in the estimates, to be the same, notwithstanding the difference we have made their lengths on the map. The estimates also suppose the lock, sluice and inner breakwater, and pier wharf, to be of same cost, as they are made out in detail for the

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Scusset line, the ground at the terminus of each line being so similar in form and character.

### Dimensions of the Canal.

The cross section of the canal has been fixed of such dimensions as will allow the largest class of coasting steamers, such as the Metropolis of Fall River, to pass each other without interference while under easy headway; these dimensions are as below: —

| | | | | | |
|---|---|---|---|---|---|
| Width at bottom of canal, | | | | . | 120 feet. |
| " | 10 feet above bottom, | exclusive of berms, | | . | 150 " |
| " | 10 " | " | including berms, | . . | 180 " |
| " | 18 " | " | at water line, | . . | 204 " |
| " | 24 " | " | exclusive of tow-paths, | | 222 " |
| " | 24 " | " | including tow-paths, | . | 252 " |

Above the tow-paths, the sides of the excavation will have slopes of $1\frac{1}{2}$ to 1, with a berm of three feet at every twelve feet vertical height.

By leaving the two submerged berms of fifteen feet width each, much excavation is saved, without incommoding the large side-wheel steamers in their passage through the canal, for their wheels would not touch the berms, over which they would be often brought in passing other large vessels. These berms would be useful in supporting a partial pitching of the canal slopes, to prevent erosions of the banks by the waves and surges of passing boats. The estimate does not include the cost for pitching or paving the slopes, supposing some other cheaper protection would be adopted for this purpose near the water edge.

My instructions from your Committee were to plan a canal with locks to allow a free passage for large steamers through it of the size of the above-mentioned Steamer Metropolis, Captain Brown, plying between Fall River and the City of New York, and from Mr. Pierce, a member of the Committee, I received the following dimensions of that vessel:

| | | |
|---|---|---|
| Length over all, | . . . . . | 342 feet. |
| Breadth of beam, | . . . . . | 45 " |
| Breadth over all, | . . . . . | $86\frac{1}{6}$ " |
| Depth of hold, | . . . . . | 16 " |
| Draft of water, | . . . . . | $10\frac{1}{2}$ " |

Afterwards, on making a visit to the Metropolis at Fall River, for the purpose of getting her cross-section, Captain Brown informed me her actual length and breadth measured over all, was 345 feet, and 88 feet 6 inches. From these latter measurements have the dimensions of the canal and locks been fixed. The captain mentioned a fact of importance in fixing upon the least radius a canal could have for the modern long

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steamers; stating that the Metropolis, like many others of her class, would turn when at quick speed in an open sea, on a curve having a diameter of three times the length of the vessel, or 1,026 feet. The diameter of the curve of the greatest deflection, is about 5,400 feet, a curve probably none too large for two such steamers as the Metropolis to pass each other with ease.

### Construction of the Locks.

The dimensions required for the locks, to pass the largest class of steamers now used in the coasting trade, such as the side-wheel Metropolis, discourages the engineer from following the ordinary mode of forming them with mitre-gates. I therefore conceived at the outset that a floating or sliding caisson must, if possible, be proposed in the present case, and was fortunate to find the description of one of this kind in a lecture delivered by Mr. Samuel Clegg, Jr., before the United Service Institution, June 14th, 1854, published in the Civil Engineer and Architect Journal for July, 1854. The gate described was applied to the outer end of the entrance lock to the south basin of the government dock at Keyham, as an experiment, and according to Mr. Clegg's account of it, was a success. The gate was designed by Mr. Scamp and constructed by Mr. William Fairbain, of Manchester; the lock was, as the description states, "260 feet long, 80 feet wide, and 43 feet deep, and the inner extremity being provided with a caisson of the ordinary construction, the water can be pumped from between the gates, and a dry dock obtained." "The sliding-gate on such an occasion has to sustain a pressure of about 1,700 tons arising from the entire depth of water at spring tides, which is about 38 or 39 feet;" "the caisson at top is 82 feet 6 inches, and at bottom 68 feet 6 inches, the height being 42 feet, exclusive of the falling hand-rail." "The beam of the vessel is 13 feet 6 inches, and with the timber linings 14 feet 10 inches. The distance between the two plane faces of the masonry is 15 feet 6 inches." "The whole of the bottom or hold is formed into a perfectly tight air-chamber, of such capacity as to make the vessel buoyant to the extent of 10 or 12 inches; and being thus free from contact with the sill, it is easily floated into the recess. Above this air-chamber is what is called the tidal ballast compartment, into which the water has admission through two sluices, and permitted to ebb and flow with the tide." "The third compartment forms a tank capable of holding sixty or seventy tons of water, which being filled from hose-pipe connected with the water mains of the dock-yard, sinks the caisson into its place." "It is drawn in and out of the recess by chains attached to each end, and to small drums on the working gear. There are also two guide-ropes, which after passing through the caisson immediately below the upper deck, are secured to

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the north recess by spring hooks upon links fixed in the masonry. The ends of the guide-ropes are connected with the machinery of the hauling chains, and are wound upon barrels in the south recess." "Under ordinary circumstances, where economy is a consideration, and where dock entrances of large size have to be closed, Mr. Scamp's 'self-acting' caisson (if I may use the term,) may be employed. And also, that the sliding caisson possesses the advantage of speed in working, and may be used in any situation."

Mr. Clegg further states: "An inquiry of some interest is opened, when an engineer has to decide upon the use of turning-gates or of caissons,—they both have their advantages, and both their disadvantages. For openings up to 60 feet wide, where the water does not rise higher than perhaps 20 feet, turning-gates, I think, would be preferred to the common caisson gates, since they are always in their places, and the time required to dock or undock a ship is less than that occupied in lifting, floating away, and returning the caisson. With the *sliding* caisson, as designed by Mr. Scamp, these objections do not exist. The disadvantages of large dock-gates are,—First, their original cost, which is greater than that of a caisson. Secondly, they are more frequently in need of repairs; and the rollers at the bottom, or the step of the heel-post get damaged, their depth below water is a serious obstacle to their renewal. The third disadvantage of large and deep turning-gates is, their liability to buckle and leak; and it is not a difficult thing to imagine that such large surfaces are sometimes pressed out of truth, and any want of parallelism between the heel and mitre-posts will prevent them from meeting with that precision absolutely essential to prevent leakage. There is of necessity some leakage even through those gates exposed to the least depth of water. The leakage through equal openings increases with pressure arising from increased head; and as the difficulty of keeping gates tight also increases with their vertical and longitudinal dimensions, it follows that there must be some practical limit to the use of turning-gates; and if we assume this limit to be 70 feet in opening, and 25 feet in depth of water, we shall have to use a caisson-gate for openings of greater width and depth."

This extended quotation is given, as it saves much explanation, and is, so far as I am informed, the only description yet published of this form of sliding-gate, and which has encouraged me in designing a lock for its application; it greatly simplifies the mason work, and no doubt equally reduces the cost, requiring only three gates with recesses, instead of six pairs of the more costly turning-gates with their recesses parallel to the side walls of the lock, each pair breaking the continuity of the invert, which has to resist the upward pressure of the water under the foundation. It is to be hoped such a form of gate can be worked as

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successfully in this climate as the old mitre-gate; in our opinion they will answer equally as well.

Plans and sections of the locks and feeding sluice on a small scale are given on the map, and show the character of these works. In constructing them, it is proposed to follow the French method of making monolithic foundations in concrete by immersion, which saves the cost of the usual expensive form of coffer dams, and afterwards the expensive drainage of the enclosure, during the work of laying the foundation and greater portion of the superstructure. In France, this mode of founding large works, where water has to be contended with, has been in use for many years with more or less success, and the experience and skill acquired by their able engineers in this process is such, that at the present time it is preferred to all others, both for its cheapness and solidity; it is true they have the pouzzolana of Italy, so energetic and well adapted for the purpose when mixed with a fat lime, similar to our Thomaston lime. The pouzzolana is always used when it can be obtained at the locality at a reasonable rate; sometimes they use both natural and artificial hydraulic cement for the same purpose, but nothing has yet been quite so good as the pouzzolana of Italy. Although we have little if any experience in this country in this process of immersing concrete, made of our hydraulic lime cement, still it has been suggested by our writers on the subject, and I have confidence the process would be successful, if tried. At Fort Warren, where much concrete was used for various purposes, its cost, according to Mr. Wright who wrote on the subject, was for the better kinds $3.50 a cubic yard, or a little less than 13½ cents a cubic foot, when the hydraulic lime cement cost one-half a cent a pound, or $1.50 for a cask of 300 pounds. For the works proposed at Scusset and Back River, the price has been fixed at 12 cents a cubic foot.

In preparing for running the concrete, after dredging the area required for the foundation to a uniform level and proper depth, a row of round piles are to be driven 2½ feet apart the entire outline the concrete is to have, except the side next to the sea, which is left open; the piles after being driven are to be secured at top between two ribbons drawn hard against their sides, thus forming an enclosure within which the concrete is to be run from a series of float-stages extending across the enclosure from the row of piles one side to the opposite row. Outside the piles staging and bridges are to be erected for the mortar mills, and convenience of the laborers who have to transport the prepared concrete from the mills to the float-stages where it is sunk in boxes to its place in the foundation. The work is commenced at the closed end of the enclosure and finished at the open end opposite, depositing so much concrete as will produce a uniform thickness of nine or ten feet. When this mass

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has hardened sufficiently, a series of moulds for shaping the side walls are set up within the enclosure at the proper distance from the piling, and secured strongly in their places by shores and timber ties. In doing this part of the work preparatory to running the side walls, moulds are to be set up across the head and foot of the enclosure for the coffer dams in concrete, which are run simultaneously with the side walls to which they are united, both being brought up to a proper height; an enclosure will be formed for keeping out the water while the interior of the lock is being laid with the rubble and cut-stone masonry. These side walls and coffer dams may be carried up to the level of high tide if required, but in the estimate they are only supposed to be raised to the height of half tide, for when at this height other means of keeping out the water may be used; the embankments on the sides may then be brought up and made to serve as dams until the interior work is finished, after this is done the coffer dams are to be carefully quarried out hollow, down to level of the lowest part of the invert of the lock, and then suddenly demolished by charges of gunpowder at bottom, the debris being afterwards removed by dredging and diving bell.

Near the end of the middle recess of the lock, and in line with it, will be placed an engine with a pump-well descending from its interior to a level a little below the bottom of the recess, where the well and recess will be connected by a culvert, in which is a stop-gate for cutting off, at will, the communication. An engine of forty-horse power would be set up in connection with the pumps in the well, furnishing the means of pumping out the water from the lock chamber, in case repairs are required to the gates seats, any one of the gates, or to any part of the interior masonry, provided, in case the entire length of the lock is to be laid dry, two of the gates are floated beforehand, out of their recesses, and dropped into the seats prepared for them at the extreme ends of the outer inverts. For such use and for repairs to the gates themselves, they will be so constructed as to allow of their being floated out of their proper places in the recesses. They can also be used for laying dry the feeding sluice that will be built alongside the Scusset lock. Nothing like this could be done with turning gates of the usual form, should they be used instead of the sliding caisson gates.

The engine-house and pump-well at Scusset would be placed between the middle recess of the lock and central recess of the sluice, the well being in communication with both by tunnels with stop-gates in them, allowing either the sluice or the lock to be emptied independently of the other for repairs, and we may add that in urgent cases the latter may be used for a dry dock, if previously fitted for such a use in cutting steps for shores in the masonry, and lewis holes for securing the keel-blocks. The steam-engine would probably be used for working the sliding



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caissons, by means of chains conducted over pullies either above ground or in covered channels underneath; also for pumping water for regulating the flotation of the gates in case the Keyham arrangement is followed; there water was required because the engineer decided not to have the caisson traverse on wheels, a plan that probably would have obviated the use of water. Wheels or rollers, we are of opinion, can be applied advantageously, especially in this climate, where the water introduced into the upper part of the caisson would freeze more or less in very cold weather; nevertheless, should a supply of water be required for this use, for feed water to engine boilers, or for domestic wants, water pipes might be laid down along the canal tow-path to North Sandwich, thence up Herring Pond outlet, as far as necessary to obtain the full pressure of Herring Pond as a reservoir.

As shingle, gravel and sand, can be easily obtained from the neighboring beaches at both locks, and the hydraulic cement and lime readily delivered from sea-going vessel directly upon the works, there can be no question but what the concrete and hydraulic mortar can be furnished for the two locks at a very reasonable rate.

The stone for the rubble and ashlar work of the Scusset lock, may be obtained from some of the granite quarries that now supply Boston, probably from Cape Ann; from the extensive quarries of Messrs. Eames, Stimson & Co., at Rockport Village, Messrs. B. Colburn & Co., at Pigeon Cove, and the other intermediate quarries, all on the easterly side of the Cape, where the stones are massive, solid, and of a durable quality. We have examined several of these quarries, and ascertained the prices demanded for the stone. Messrs. Eames, Stimson & Co. would furnish rubble of ordinary size for the locks and breakwaters, at one dollar per ton; the dimension stones of large size for the ashlar of the lock, 30 cents per cubic foot in the rough; their price for cutting the face, 25 cents; for cutting the beds, builds and joints, 10 cents per square foot.

The rubble-stone and probably some of the large ashlar for Back River lock, we suppose could be procured from the Mattapoisett quarry, which is, we believe, the nearest point where "*rock in place*" has been quarried. This is distant about 13½ miles from Back River Harbor; the quarry appears not to have been worked with modern skill, and its capacity for furnishing good ashlar stone is not known. It is considered at the locality that cut-stone may be delivered at Back River Harbor, from the State of Maine, as cheaply as from this quarry. Our informant, referring to the contract made by government for the ashlar cut-stone then being delivered at the fortification at New Bedford, that is, at the rate of 40 cents per cubic foot.

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DIMENSIONS OF THE LOCK AND SLUICE.

| | | |
|---|---|---|
| Length of lock at top of coping, including wing-walls, | 556 | ft. |
| " of concrete foundation, including bases of coffer dams, | 602 | ft. |
| Width of lock chamber at top of coping, | 96 | ft. |
| " of lock chamber at chord of invert or at foot of batter sides, | 80 | ft. |
| " of concrete foundation at bottom, | 120 | ft. |
| Vertical height of batter sides, | 24 | ft. |
| Versed sine of invert of Scusset lock, | $9\frac{35}{100}$ | ft. |
| " " " of Back River lock, | $7\frac{38}{100}$ | ft. |
| Thickness of concrete foundation under inverts, Scusset lock, | 10 | ft. |
| " " " " " recesses, " " | 8 | ft. |
| " " " " " inverts, Back River lock, | 9 | ft. |
| " " " " " recesses, " " " | 7 | ft. |
| " of concrete side walls of both locks, | 13 | ft. |
| Height of concrete side walls, before quarrying recess, Scusset lock, | 27 | ft. |
| Height of concrete side walls, before quarrying recesses, Back River lock, | 25 | ft. |

| | | | |
|---|---|---|---|
| Width of exterior, or coffer dam, recesses at ends of lock, | 18 ft. each, | 36 | ft. |
| Projection of circular walls outside these recesses, | 15 ft. each, | 24 | ft. |
| Length of inverts outside sliding-gate recesses, | 60 ft. each, | 120 | ft. |
| Width of the two outer sliding-gate recesses, | 18 ft. each, | 36 | ft. |
| Length of the longest or inner lock chamber next to canal, | | 200 | ft. |
| Width of middle-gate recess, | | 18 | ft. |
| Length of the shortest or outer lock chamber, next to sea, | | 132 | ft. |
| Total length of lock at top of coping, | | 566 | ft. |

| | | |
|---|---|---|
| Length of each of the three sliding-gate recesses, measured from side of lock at top of coping, | 103 | ft. |

The cross section of the Scusset feeding sluice is the same as in the adjoining lock, except it has no sliding-gate recess; also the coffer dam recesses and middle gate recess, are of same form.

| | | |
|---|---|---|
| Length of sluice inverts, inside and outside the sluice-gates, 50 ft. each, | 100 | ft. |
| " of sluice, exclusive of the wing-walls, but including recesses and inverts, | 154 | ft. |
| Length of concrete foundation, including bases of coffer dams, | 190 | ft. |
| Width of concrete foundation, where it does not interfere with the foundation of the engine-house, | 120 | ft. |
| Depth of water, at mean low tide, on invert of Scusset lock, | $18\frac{42}{100}$ | ft. |
| " " " " " Back River lock, | $18\frac{94}{100}$ | ft. |
| " " " high tide, on invert of Scusset lock, | $27\frac{59}{100}$ | ft. |
| " " " " " Back River lock, | $23\frac{05}{100}$ | ft. |
| Top of coping above lowest part of invert, Scusset lock, | $33\frac{38}{100}$ | ft. |
| " " " " " " Back River lock, | $31\frac{38}{100}$ | ft. |

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The great sluice-gate or bulkhead to be placed in the central recess of the sluice-way, would be constructed of wrought-iron in outline—similar to one of the sliding-gates of the lock—and be pierced by 24 or more openings of five feet square, each to be closed by a balance paddle gate in the form of those often used in canal locks, which are easily opened and shut, and may be made self-acting, to allow the flood-tides to flow into the canal while they are above its level; the gates closing on the fall of the tide, against the issue of any water from the canal.

### Supply of Water to Canal.

For fixing the proper level of the canal surface, we had only the Observations of Mr. Mitchell to guide us. This report contained two tidal diagrams, No. 1 and No. 2, which have been used as the basis of our computations for this purpose. No. 1 was of great value, as it gave the form of the tidal wave, from which we were enabled to ascertain approximately the quantity of water that could be supplied to the canal through the feeding sluice and by leakage, as well as the waste by lockage from the canal.

The observations of Barnstable Bay tide could alone be used in computing the supply to the canal, for the high tides of Buzzard's were too low to serve as feeders at the level it was desirable to adopt, that was four feet above the mean level of the sea, a level, it will be observed by referring to Mr. Mitchell's diagram No. 2, no tide reached during the period of 27 days' observations in that bay, from July 20th to Aug. 17th, 1860; and only one tide during the same period rose higher than three feet above mean sea level. Such being the fact, the high tides in Buzzard's Bay, in this relation, were to be disregarded and only considered, in settling upon the proper level for the bottom of the lock chamber and channel to be dredged, thence out to deep water.

On inspecting the high water line of Barnstable Bay, on the diagram No. 2, it was supposed the level of four feet above mean tide would serve for the high water level of the canal, and the computations have been made on this supposition; that is, the amount of excavation required for the trunk of the canal, as computed from Mr. Chase's book of cross sections, herewith submitted to the Committee; it is now proposed to add to the amount of earth work referred to, a further amount, in case it should be found necessary or advisable to make sure of 18 feet draft of water through the canal, by adding two feet to the depth of cutting for a breadth of 80 feet along the middle of the canal, producing a very flat slope of 10 to 1 on each side of 20 feet in width. This addition to the depth of cutting would make it practicable to navigate the canal with vessels drawing 18 feet on the most trying occasions of excessive lockage, during a very low course of neap tides. If dredging succeeds

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in removing the earth from the bottom of the canal in the first instance, this deepening can be omitted until, by trial, it is found indispensable.

The following table shows the amount of water that would be discharged into the canal through 24 sluices, each five feet square, inserted in the great bulkhead of the feeding sluice-way, during such a course of tides as occurred between the 17th July and 17th August, 1860, as exhibited on Mr. Mitchell's diagram No. 2. Supposing the level of the canal surface to be kept constantly at four feet above the mean level of the sea for the first column, 3.50 feet for the second, and three feet for the third.

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## *Water Supplied to Canal by Tide.*

| Surface of Canal 4 Feet above Mean Tide. | | | Surface of Canal 3.50 Feet above Mean Tide. | | | Surface of Canal 3 Feet above Mean Tide. | | |
|---|---|---|---|---|---|---|---|---|
| DATE. | Time of Day. | Cubic Feet. | DATE. | Time of Day. | Cubic Feet. | DATE. | Time of Day. | Cubic Feet. |
| **1860.** | | | **1860.** | | | **1860.** | | |
| July 17, . . . | P. M. | 37,636,416 | July 17, . . | P. M. | 47,230,992 | July 17, . . | P. M. | 60,148,848 |
| 18, . . . | A. M. | 11,210,160 | 18, . . | A. M. | 19,098,000 | 18, . . | A. M. | 29,308,320 |
| 18, . . . | P. M. | 40,309,776 | 18, . . | P. M. | 49,692,288 | 18, . . | P. M. | 62,187,936 |
| 19, . . . | A. M. | 18,210,544 | 19, . . | A. M. | 27,196,800 | 19, . . | A. M. | 35,786,496 |
| 19, . . . | P. M. | 42,508,304 | 19, . . | P. M. | 52,107,696 | 19, . . | P. M. | 64,752,768 |
| 20, . . . | A. M. | 27,196,800 | 20, . . | A. M. | 35,786,496 | 20, . . | A. M. | 47,230,972 |
| 20, . . . | P. M. | 47,230,992 | 20, . . | P. M. | 60,148,848 | 20, . . | P. M. | 72,893,616 |
| 21, . . . | A. M. | 38,116,416 | 21, . . | A. M. | 47,230,972 | 21, . . | A. M. | 60,148,848 |
| 22, . . . | A. M. | 47,230,972 | 22, . . | A. M. | 60,148,848 | 22, . . | A. M. | 72,893,616 |
| 22, . . . | P. M. | 29,308,320 | 22, . . | P. M. | 40,309,776 | 22, . . | P. M. | 52,107,696 |
| 23, . . . | A. M. | 38,116,416 | 23, . . | A. M. | 43,390,992 | 23, . . | A. M. | 60,148,848 |
| 23, . . . | P. M. | 27,196,800 | 23, . . | P. M. | 35,786,496 | 23, . . | P. M. | 47,230,972 |
| 24, . . . | A. M. | 27,196,800 | 24, . . | A. M. | 35,786,496 | 24, . . | A. M. | 47,230,972 |
| 24, . . . | P. M. | 23,206,320 | 24, . . | P. M. | 33,565,440 | 24, . . | P. M. | 34,847,120 |
| 25, . . . | A. M. | 7,268,960 | 25, . . | A. M. | 15,117,696 | 25, . . | A. M. | 27,196,800 |
| 25, . . . | P. M. | 19,098,000 | 25, . . | P. M. | 29,308,320 | 25, . . | P. M. | 40,309,776 |
| 26, . . . | P. M. | 19,098,000 | 26, . . | A. M. | 5,326,656 | 26, . . | A. M. | 15,117,696 |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July | 27, | . . | P. M. | 23,206,320 | July | 26, | . . | P. M. | 29,308,320 | July | 26, | . . | P. M. | 40,309,776 |
| | 28, | . . | P. M. | 15,117,696 | | 27, | . . | A. M. | 3,504,240 | | 27, | . . | A. M. | 13,100,880 |
| | 29, | . . | P. M. | 19,098,000 | | 27, | . . | P. M. | 33,565,440 | | 27, | . . | P. M. | 34,847,120 |
| | 30, | . . | A. M. | 991,200 | | 28, | . . | A. M. | 1,592,640 | | 28, | . . | A. M. | 11,210,160 |
| | 30, | . . | P. M. | 23,206,320 | | 28, | . . | P. M. | 25,219,200 | | 28, | . . | P. M. | 35,786,496 |
| | 31, | . . | A. M. | 3,504,240 | | 29, | . . | A. M. | 3,504,240 | | 29, | . . | A. M. | 13,100,880 |
| | 31, | . . | P. M. | 27,196,800 | | 29, | . . | P. M. | 29,308,320 | | 29, | . . | P. M. | 40,309,776 |
| Aug. | 1, | . . | A. M. | 991,200 | | 30, | . . | A. M. | 8,856,368 | | 30, | . . | A. M. | 19,098,000 |
| | 1, | . . | P. M. | 19,098,000 | | 30, | . . | P. M. | 33,565,440 | | 30, | . . | P. M. | 34,847,120 |
| | 2, | . . | A. M. | 3,504,240 | | 31, | . . | A. M. | 13,100,880 | | 31, | . . | A. M. | 23,206,320 |
| | 2, | . . | P. M. | 21,147,840 | | 31, | . . | P. M. | 38,116,416 | | 31, | . . | P. M. | 49,692,288 |
| | 3, | . . | A. M. | 991,200 | Aug. | 1, | . . | A. M. | 8,856,368 | Aug. | 1, | . . | A. M. | 19,098,000 |
| | 3, | . . | P. M. | 11,210,160 | | 1, | . . | P. M. | 29,308,320 | | 1, | . . | P. M. | 40,309,776 |
| | 4, | . . | A. M. | 991,200 | | 2, | . . | A. M. | 13,100,880 | | 2, | . . | A. M. | 23,206,320 |
| | 5, | . . | A. M. | 11,210,160 | | 2, | . . | P. M. | 31,191,840 | | 2, | . . | P. M. | 42,508,304 |
| | 6, | . . | A. M. | 3,504,240 | | 3, | . . | A. M. | 8,856,368 | | 3, | . . | A. M. | 19,098,000 |
| | 6, | . . | P. M. | 7,268,960 | | 3, | . . | P. M. | 19,098,000 | | 3, | . . | P. M. | 29,308,320 |
| | 7, | . . | P. M. | 7,268,960 | | 4, | . . | A. M. | 8,856,368 | | 4, | . . | A. M. | 19,098,000 |
| | 8, | . . | P. M. | 5,326,656 | | 5, | . . | A. M. | 19,098,000 | | 5, | . . | A. M. | 29,308,320 |
| | 9, | . . | P. M. | 1,592,640 | | 5, | . . | P. M. | 7,268,960 | | 5, | . . | P. M. | 17,094,432 |
| | 10, | . . | P. M. | 991,200 | | 6, | . . | A. M. | 13,100,880 | | 6, | . . | A. M. | 23,206,320 |

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*Water Supplied to Canal by Tide*—Continued.

| Surface of Canal 4 Feet above Mean Tide. | | | Surface of Canal 3.50 Feet above Mean Tide. | | | Surface of Canal 3 Feet above Mean Tide. | | |
|---|---|---|---|---|---|---|---|---|
| DATE. | Time of Day. | Cubic Feet. | DATE. | Time of Day. | Cubic Feet. | DATE. | Time of Day. | Cubic Feet. |
| **1860.** | | | **1860.** | | | **1860.** | | |
| Aug. 11, . . . | P. M. | 1,592,640 | Aug. 6, . . | P. M. | 15,309,696 | Aug. 6, . . | P. M. | 27,196,800 |
| 12, . . . | P. M. | 3,504,240 | 7, . . | A. M. | 7,268,960 | 7, . . | A. M. | 17,094,432 |
| 13, . . . | P. M. | 15,117,696 | 7, . . | P. M. | 17,094,432 | 7, . . | P. M. | 27,196,800 |
| 14, . . . | P. M. | 27,196,800 | 8, . . | A. M. | 5,326,656 | 8, . . | A. M. | 15,309,696 |
| 15, . . . | A. M. | 11,210,160 | 8, . . | P. M. | 15,309,696 | 8, . . | P. M. | 25,219,200 |
| 15, . . . | P. M. | 33,565,440 | 9, . . | A. M. | 1,592,640 | 9, . . | A. M. | 11,210,160 |
| 16, . . . | A. M. | 13,100,880 | 9, . . | P. M. | 11,210,160 | 9, . . | P. M. | 21,147,840 |
| 16, . . . | P. M. | 52,107,696 | 10, . . | P. M. | 8,856,368 | 10, . . | A. M. | 991,200 |
| 17, . . . | A. M. | 31,191,840 | 11, . . | P. M. | 11,210,160 | 10, . . | P. M. | 19,098,000 |
| | | | 12, . . | P. M. | 13,100,880 | 11, . . | A. M. | 991,200 |
| | | | 13, . . | P. M. | 25,219,200 | 11, . . | P. M. | 21,147,840 |
| | | | 14, . . | A. M. | 1,592,640 | 12, . . | P. M. | 23,206,320 |
| | | | 14, . . | P. M. | 38,116,416 | 13, . . | A. M. | 991,200 |
| | | | 15, . . | A. M. | 21,147,840 | 13, . . | P. M. | 35,786,496 |
| | | | 15, . . | P. M. | 34,847,120 | 14, . . | A. M. | 11,210,160 |
| | | | 16, . . | A. M. | 23,206,320 | 14, . . | P. M. | 49,692,288 |
| | | | 16, . . | P. M. | 64,752,768 | 15, . . | A. M. | 31,191,840 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Aug. 15, | . | . | 57,176,784 |
| | | | | | | | 16, | . | . | 33,565,440 |
| | | | | | | | 16, | . | . | 77,552,784 |
| | | | | | | | 17, | . | . | 54,581,424 |
| Total cubic feet, | . | . | 896,144,620 | Aug. 17, | . | . | 42,508,304 | Total cubic feet, | . | 1,968,843,812 |
| | | | | Total cubic feet, | . | . | 1,373,280,556 | | | |



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The above table exhibits the volume of water that would enter the canal through the sluice gates only, but during the time the tide is above the canal level, vessels would be locking into or out of the canal, discharging into it an additional quantity of water; the amount depending upon the height of the tide and rapidity with which the vessels are passed. To give some idea of the amount from this source of supply, I present the following results of computations, based on the high tide that occurred August 14th, 1860, at the 21st hour, and represented on Mr. Mitchell's diagram No. 1:

| | Cubic feet. |
|---|---|
| With the surface of the canal at 4 *feet above mean tide*, 7 vessels or lockages could be made while the tide was above this level, assuming it took about 26 minutes for each vessel; and the aggregate volume of water discharged into the canal would be 234,005 cubic feet, which multiplied by the number of tides, viz., 47, that rose above the 4 feet level between 17th July and 17th August, 1860, we get the volume of water to be added to the column of the foregoing table, marked 4 feet above mean tide, 234,005×47, . . . . . | 10,998,235 |
| Add foot of column marked 4 feet above mean tide, . . | 896,144,620 |
| Total cubic feet of water supplied to canal at Scusset, in 47 tides, . . . . . | 907,142,855 |
| With the surface of the canal at 3.50 *feet above mean tide*, 8 vessels could pass the lock while the tide remained above that level, allowing as before about 26 minutes for each lockage, the aggregate is found to be 365,472 cubic feet, which multiplied by 56, the number of tides that rose, during the month, above the 3.50 feet level, 365,472×56, . . . | 20,476,544 |
| Adding foot of column marked 3.50 feet above mean tide, . | 1,373,280,556 |
| Total cubic feet of water discharged into canal in 56 tides, . | 1,393,757,100 |
| With the canal at 3 *feet above mean tide*, 8 vessels would pass the lock while the tide remained above this level, allowing 26 minutes to each,—and the aggregate discharge obtained is 522,546 cubic feet, this multiplied by 59 tides that rose during the month above this level, 522,546×59, . | 30,830,214 |
| Adding the third division or column of the table marked 3 feet above mean tide, . . . . . | 1,968,843,812 |
| Total cubic feet discharged into canal in 59 tides, . . . | 1,999,674,026 |

We have now to see how much water would approximately be consumed by a constant lockage, kept up at both ends of the canal; that used at the Scusset lock being based on the supposition that all the

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tidal waves for each of the sixty high tides observed there by Mr. Mitchell, and represented on his diagram No. 2, were of the same height and similar in form, to the wave represented on his diagram No. 1, whose crest passed Scusset August 14th, at the 21st hour. That used at Back River lock being based on sixty tidal waves, all of them like that represented on the same diagram, whose crest passed Back River Harbor at 5th hour, August 14th. The results are as follows:

| | Cubic feet. |
|---|---|
| Surface of canal being kept at 4 *feet above mean tide*, it is found that the volume of water that would be drawn from the canal, at Scusset lock, in locking through 22 vessels or using 22 lock prisms, at the rate of about one in 26 minutes, would be equal to 4,142,093 cubic feet per tide, which sum multiplied by the 60 tides, produces for the month, . . | 248,525,580 |
| Surface of canal supposed to be kept at same height, the water used at Back River lock in locking through 27 vessels, at the rate of about one in 26 minutes, or same number of lock prisms, the quantity would amount to 4,346,067 cubic feet per tide, this multiplied by 60 tides, gives for the month, . | 260,764,020 |
| Total loss of water by lockage with canal at 4 feet level, . | 509,289,600 |

| | Cubic feet. |
|---|---|
| Supply to canal through sluice and lock at Scusset for the month, the canal being kept at 4 feet level, as per previous statement, . . . . . | 907,142,855 |
| Deduct the loss of water by lockage, as per above statement, . | 509,289,600 |
| Amount of water left in canal at end of month to supply leaks evaporation and filtration, or for use as mill power, . . | 397,853,255 |

| | Cubic feet. |
|---|---|
| Surface of canal remaining constant at 3.50 *feet above mean tide*, the amount of water used at Scusset lock in locking through 20 vessels, would be 3,619,484 cubic feet per tide, which multiplied by 60 tides is . . . . . | 217,169,040 |
| Add lockage at Back River lock with canal at same level equal to 3,839,531×60 tides, . . . . . | 230,371,860 |
| Total loss by lockage with canal at 3.50 feet level, . . . | 447,540,900 |

| | Cubic feet. |
|---|---|
| Supply to canal through sluice and lock at Scusset, while surface of canal remains at 3.50 feet level, per statement, . | 1,393,757,100 |
| Deduct the loss of water by lockage, per last statement, at 3.50 level, . . . . . | 447,540,900 |
| Amount of water remaining in canal at end of month, for supplying leakage, evaporation, filtration or mill power, . | 946,216,200 |

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| | Cubic feet. |
|---|---|
| Surface of canal kept at 3 *feet above mean tide*, the amount of water drawn at Scusset in locking through 20 vessels, is equal to 3,369,049 cubic feet per tide, and multiplied by 60 tides, gives . . . . . | 202,142,940 |
| Add lockage at Back River lock for 27 vessels, with canal at same level, equal to 3,339,208, multiplied by 60 tides, . . | 200,352,480 |
| Total loss from canal by lockage, under 3 feet level, . . | 402,495,420 |

| | Cubic feet. |
|---|---|
| Supply to canal through Scusset lock and sluice, canal kept at 3 feet level, as per previous statement, . . . . . | 1,999,674,026 |
| Deduct above loss by lockage, at 3 feet level, . . . . | 402,495,420 |
| Amount of water remaining in canal at end of month, for supplying locks, mill power, &c., . . . . . | 1,597,178,606 |

It should be mentioned that the particular tide at Scusset used in the foregoing calculations, was somewhat greater than the mean of the sixty tides considered, and consequently gives the amount of water drawn from the canal in excess of the mean; this is in favor of the calculations and gives confidence in the results, as stated above. Also the particular tide used for the Back River lockage, was in its elevation a little less than the mean; the low water of the wave at commencement was about $\frac{2}{10}$ths of a foot above, and at the end about the same ($\frac{2}{10}$ths) below the average corresponding to the mean low water there. But the crest of the wave did not reach the mean high water level by $\frac{3}{10}$ths of a foot, consequently the computations based on this tide are on the safe side.

By the three last comparative statements, it is to be observed, that the excess of water remaining in the canal at the termination of the 60 tides is so great, as to preclude the idea of a deficiency of supply, even at the highest level assumed for the canal, provided the water can be stored for the lockage. The surplus in the first case, amounting to 78 per cent. of the total lockage for the month considered; the surplus in the second statement, where the canal level is called 3.50 feet, amounts to 211. per cent.; and in the third statement, canal called 3 feet above mean tide, amounts to 397. per cent., or nearly four times the quantity of water used in locking during the month.

For obtaining and retaining the surplus water, it is evident a large reservoir is required to prevent as much as possible the fluctuation of the canal surface, consequent on an intermittent feeder, which is unavoidable in this work, where the supply comes from the tide.

The superficial area of the canal proper, with its two basins, will be about 8,200,000 square feet; and to supply the lockage for a single tide with canal at 4 feet standard level, that area must be drawn down more

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than one foot. With canal at 3.50 feet level, it would be reduced $\frac{9}{10}$ths of a foot, and at 3 feet level a little more than $\frac{8}{10}$ths of a foot.

To prevent this fluctuation of the canal level, and to hold a supply for neap tides, it will be necessary eventually to connect the canal with Buttermilk Bay, which it is easy to do by a shallow cut from the lower part of the Monumet River, along the proposed new location for the railroad; the embankment for the railroad across the Monumet would form the dam for retaining the waters of the bay at the level of the canal, after an embankment had been made across Buttermilk Bay outlet, where the railroad now passes by a pier and draw-bridge.

Back River, with its bordering marshes and ponds, may be easily converted into a reservoir of some five or six millions square feet, by erecting a dam where it enters Back River Harbor, and uniting it to the canal by a short and easy cut through Salt Pond, near the head of the Back River lock; this plan is suggested on the supposition that the marshes on that river are no higher than those on the Monumet, that is, 1.39 feet under the proposed standard level of the canal.

The great Sagamore marsh of nearly a square mile in area, say 24,000,000 square feet, about three times the area of the canal surface, could be isolated from the sea and joined to the canal; but it would only be partially useful, in serving for a reservoir after the canal had been swelled by the tide about six inches above the 4 feet standard level. except to the extent of the area occupied by the creeks and drains that traverse it in all directions, which would supply water down to the 4 feet standard level and even lower. If the marsh was purchased and diked out, both from the sea and canal, with proper feeding sluices communicating with both, the marsh might possibly be made to receive the spring tides and retain a large quantity of water, to be drawn for canal use during the neap tides. The marsh covered to the depth of one foot with water, would be nearly equivalent to the waste by lockage during three tides.

Should only that part of the marsh north and west of Sagamore Hill be enclosed, the area would be about one-third of the whole, or about equal to the superficial area of the canal proper; and could only furnish water for lockage during one tide. If the surface of this part of the marsh should be removed to the depth of one foot, at a total cost of some $30,000 to $40,000, 50 per cent. would be added to its value as a reservoir, and even 100 per cent. should the canal surface be reduced six inches permanently or temporarily. In respect to the use of sluices or wears for admitting the tide-water directly from the bay on to the marshes, some uncertainty of action is to be apprehended from the effects of storms on the beach, causing the channels to the gates or wears to be filled up with stones, shingles and sand, notwithstanding the

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protection the breakwaters might afford in certain directions of the wind. However, this last mentioned portion of the marsh, including all west of Sagamore Hill up to the railroad, should be purchased at the outset, to be converted, in its present condition, into a reservoir, and afterwards, if deemed necessary, improved as suggested.

By making all the aforesaid connections, a considerable amount of fresh water would be necessarily introduced into the canal, drawn from the water sheds of the different areas mentioned. It is estimated, roughly, that all these water sheds would amount to 29 square miles, and would furnish for the use of the canal, after deducting the losses by evaporation and filtration, 2,657,990 cubic feet of water per day; and for 30 days, 79,739,700 cubic feet; which last sum would have to be added to each of the above comparative statements, showing the amount of water remaining in the canal after 30 days' lockage.

### Number of Vessels Locked per Day.

We have assumed in our previous calculations, that a vessel, or what may be considered the same, a group of two, four or six vessels, can be passed through the lock in about 26 minutes, or 55 passages per day; this rate may be too great. At Keyham, the account states, that the sliding caisson can be opened in 10 minutes and closed in 8 minutes; part of this time is supposed to be consumed in filling the ballast chamber from the water mains, to sink it into its seat across the lock, and afterwards to draw off the same water to float it again. We consider that if the gate traversed on rollers much time would be saved, and there would be no necessity for a supply of water, at least for this particular process of opening and shutting the gate; water would only be required to equalize the pressure upon the rollers, which would be constantly varying as the tide rose and fell. Allowing 30 minutes for a passage, 48 vessels could be locked through each lock in a day, being at the rate of 17,520 a year. We may assume as a practical number, 1,000 passages for the year. It might be possible, we think not advisable, on certain favorable opportunities, when the tide favored, to run a fleet through the lock into the canal with all the gates open.

### Works along Line of Canal.

The most important work needed along the course of the canal across the Cape between the two locks, is the draw-bridge for the railroad, to close a space between abutments of 120 feet, a span it was desirable to keep, to enable vessels to pass without checking their speed. This width of opening seemed to be too great for the use of the usual form of draw-bridge; and the estimate has been made for a construction similar to one of the sliding gates of the locks; the caisson being made to float

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from out of a recess, placed in one of the abutments at right angles to the course of the canal, crossing the canal and entering a shallow recess in the middle of the abutment, on that side where its end would rest on a solid bearing under water, the opposite or bark end having a similar support. The top of the caisson would carry the rails, so arranged as to be capable of being adjusted to the level of the fixed rails of the track on each side of the canal. The track on the side of the chamber would be supported by strong timber sleepers crossing the caisson chamber, their ends resting on the top of the side walls of the recess or chamber, and otherwise supported between the side walls by posts. The caisson draw would be of wrought-iron in the form of a parallelopipedon considerably longer than the span, so that it would guide itself straight across the canal into its proper rest on the abutment. It is taken for granted that hand power would answer for manœuvring it. Should, however, water mains be laid down from Herring Pond to Back River lock, the water could be drawn from it, as a partial substitute for manual labor.

At North Sandwich, a sluice-way in cut-stone masonry is designed for the admission of Herring Brook into the canal, at the same time to answer for a ferry boat harbor and landing place; its width measured parallel to the axis of the canal, to be 24 feet with 8 feet depth of water under the tow-path, when canal is at standard level, the masonry to descend to the bottom of the canal, with pavements on sides to protect the canal slopes and bottom, should the canal be laid dry for repairs. The sluice would be crossed by a draw-bridge of the same width of the tow-path.

### Construction of the Breakwaters.

In designing this part of the work, we have consulted the experience and late discussions of the engineers of Europe and our own country, and the forms which are here recommended, and which have in several instances proved so efficient, although costly, appear to us the safest to adopt for the protection of the lock and shipping at the Barnstable Bay terminus of the canal, where the exposure to the heavy north-easterly gales is so great; it is only from storms from this quarter that the works can be greatly tried, as the extremity of Cape Cod shuts off the ocean waves from N. E. by N. towards the south. The distance to the end of the Cape being about 23 miles, and about the same distance to the shore for 40 degrees towards the south, where waves of considerable magnitude may be produced in violent gales, acting on the deep water of the bay, in soundings varying from 13 to 20 fathoms. Farther south the range remains about the same, but over shoaler water, until the parallel of the shore is reached in a direction a little south of east.

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The greatest exposure is from due north 35 degrees, up to the range of Cape Race. (See detached plan of Cape Cod and the Bay, on Mr. Chase's large map.) West of north protection is at once afforded by the high banks of the coast towards Plymouth.

To make a safe harbor at Scusset, it has been found necessary to guard against gales blowing from all points of the compass, from due north to due east, or 90 degrees of the horizon. To effect this, we propose the erection of the three breakwaters represented on the map. The harbor is required for the protection of the shipping on their way to and from the canal, and for producing calm and waveless water at the lock entrance, and would be of essential value in giving an asylum to storm-beaten vessels driven inside the Cape.

The kind of structure proposed is the *rubble stone* or *rip-rap* work, formed by dropping large stones of any form from the surface of the sea; the process is a simple one, and requires but little skill other than dropping the stones in their proper places. The large breakwater now building at Portland, England, where the exposure to the open ocean is greater than here, has been taken as a model in the designs of the present work. Although we have imitated to a certain degree the original plan of that work, in introducing a crest wall of ashlar work along the tops of all three breakwaters; this part in our work, it is anticipated, may be dispensed with in the outer and western breakwaters; for it has been lately mentioned that even at the Portland work, the engineers are waiting for experience to decide whether this crest wall is required or not. As the details on the map show, the extremities of the breakwaters will be enlarged and finished off in the shape of truncated cones, one above the other, with sides of different declivities or slopes so as to resist effectually the shock of the waves, the upper slope being 5 to 1, the next below it 3 to 1, and the lower one, which reaches the bottom, 1 to 1. These are the slopes on the outer or most exposed parts, the inner or harbor slopes being for the upper part of the rubble work 3 to 1, and the lower part reaching to the bottom of the sea 1 to 1. The same arrangement of slopes are followed for the bodies of both the outer and western breakwaters. The inner breakwater has slopes on its eastern side 3 to 1 for the upper part, and 1 to 1 on its lower part; on its western side, which carries the parapet wall and is covered by the wooden pier wharf, the upper slope abutting the parapet wall is $1\frac{1}{2}$ to 1, and bottom slope 1 to 1. The conical heads of all the breakwaters would be crowned by a circular mass of cut-stone masonry, with a hearting of concrete 30 feet high, $61\frac{1}{2}$ feet diameter at bottom, and 54 feet diameter at top, founded in the body of the rubble at level with low water spring tides, and rising 16 feet above the rubble. Should the crest walls ever become essential for protecting the rubble

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work, or for causing smoother water in the harbor, they would be connected with these circular heads and form one mass with them.

Should the Deep-Cut or Scusset route be taken for the canal, and for many reasons we are inclined to recommend it, there might be made a considerable saving in the cost of both the western and inner breakwaters, by executing the two works nearly simultaneously, commencing by partially constructing the breakwaters in advance, and following up those works by a heavy and broad deposit of earth brought from the cut and deposited in front, on the sides of the breakwaters next to the sea. By this process, with comparatively few stones, sand and shingle beaches would be formed in extension of the natural ones.

Such an artificial beach once formed along the western breakwater, would be likely to remain stationary after a few years' exposure to storms; at any rate, we think it would never reach the extremity of this breakwater, and be driven into the harbor; for the more powerful and effective storms from the north to the north-east, would all tend to drive in the deposit towards the shore, and nothing perhaps for centuries could get round this breakwater. And we think it would also be a long time before the inner breakwater would be outreached by the easterly winds forcing the sands in a direction entirely opposite to their present course.

The general location of these breakwaters is thought to be as favorable as any within the range of the coast survey soundings, which have been indispensable in fixing their positions. To have carried the canal across the marshes south of Sagamore Hill, would have thrown these works into much deeper water and greatly enhanced their cost, supposing a harbor of equal area to be designed for that position. Harbor room is highly important in a work of this nature.

An important question arises in regard to the execution of the sea works. Where can the required quantity of stone be obtained? for no quarry or "*rock in plain*" has been found within many miles of the locality; nothing but granite boulders can be procured in the region bordering the Bay, from Plymouth to the easterly part of the Cape. It would be difficult and expensive to collect any considerable quantity of these for the work, and we must look elsewhere for a supply. A high granite hill on some safe harbor is required, where stone of the largest size can be easily quarried, and directly shipped to the site, with the least possible land carriage. The nearest quarry known, is that at Mattapoisett, 21 miles distant across the Cape, on the shore of Buzzard's Bay. Stones from this quarry could not be used before the canal was opened, on account of the great distance round the Cape, unless by rail over the Cape Cod Railroad and branches, to be made leading from it to the works, which would considerably increase the cost of transportation. Could the canal be opened to the proposed basin at Scusset, the



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stones might then be transferred from boats to railroad trucks, and run out on stagings, and dropped on the lines of the inner and western breakwaters.

The next nearest place where solid rock is found is Cohasset, 35 miles from Scusset; here several granite hills of two to five acres in extent, are found rising from the water edge; two of them are outside the harbor on Pleasant Cove, the other two are situated on the south side of the harbor; one of them is owned by the United States Government, and was opened for stone during the erection of Minot Ledge Lighthouse. Besides these, large elevated fields of solid rock of many acres in area, border the edge of the marsh, for more than half a mile to the east of the government quarry. The rock here has never been quarried to any extent for building stone, and probably would only be useful for the rubble work of the breakwaters—as it appears to be traversed in every direction by seams—and in many places appears more like greenstone than the sienite or granite. The fields of rock alluded to, could not be approached with boats, before a convenient canal had been cut out to deep water in Pleasant Cove.

Cape Ann was the third place visited in search of stone. Here it is abundant, and of a superior quality to that of the other places examined. It would be better suited for the rubble work of the upper and more exposed part of the breakwaters, where the action of the sea is greatest; that is, above a plane of 12 feet under low water spring tides. Below this level the sea has little effect, and consequently this lower and more bulky part of the structure may be composed of a mixture of stones of every size, from quarry chips upwards.

Excellent localities for stone are to be found at Cape Ann. Even within the harbor of Gloucester, high fields of solid granite come to the water edge, where many acres of stone may be taken away with little cost, with the important advantages of a large and safe harbor, where the stone boats could remain and take in their loads in the roughest of weather. The quarrying could also be conducted at the cheapest rate, on account of the facilities the town would afford to the men engaged in the work of quarrying and transporting the stone. Other places on the Cape would be available for obtaining stones in good weather, but the distance from Scusset would be greater. Gloucester harbor is the nearest and safest port to be found on the Cape, being 55 miles from the site of the breakwaters. Rockport is the next best and nearest port, and is about 60 miles from Scusset. Messrs. Ames, Stimson & Co., who work an extensive quarry near this port, have a high hill of granite rock that rises from their private harbor, which could be quarried at a very cheap rate for the rubble work of the breakwaters, but the twelve miles extra distance and greater exposure to vessels, might cause the

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price of stone to exceed that to be obtained within the harbor of Gloucester. The Messrs. Colburn & Co. have a small harbor, and many acres of accessible stone near Annisquam Harbor, four miles more distant than Rockport. Their private landing place, unless it could be considerably enlarged, appears to be too contracted for the large fleet of stone vessels that would be required in the transportation of the rubble and dimensions stone, that would be necessary to prosecute the work with energy. All the quarries have already on hand an enormous quantity of refuse stone, which the proprietors would be glad to sell at very reasonable rates. At there present prices for better stone than the refuse heaps, they would not charge more than one dollar a ton delivered at Scusset, or the same price now obtained at Boston for wharf stone, including the work of laying the stones into walls.

Considering the present prices of stone at Cape Ann, and the probable reduced prices that large contracts would be taken at, if the works were once commenced, we think it may be safely stated that the cost of these sea works, ton per ton, would not exceed one-half the rate of those executed at the mouth of the Delaware River.

In recommending the simple form of breakwater shown on the map, we have been influenced by considerations already alluded to, that we can safely and without cost wait for nature to inform us what amount of stone should be used in these constructions to resist her efforts. We have shown them of their maximum dimensions, of sufficient weight and solidity to oppose all the forces likely to be applied at the locality by the raging elements.

In the report of General Totten and associates to the Canal Committee, and which has greatly aided us in these investigations, a form of breakwater is suggested somewhat different from that we have based our estimates upon. Their plan seems to differ from ours chiefly in the application of a platform or grillage of logs as a base for the rubble-stone to rest upon; they do not allude to any crest-wall or cut-stone masonry as belonging to their plan. For comparison, we have assumed a form on their suggestion, and have given at the end of the following estimates one for it, applying to the inner and western breakwaters, having reduced the slopes of the rubble considerably from what we have them, omitting the crest-wall on the western, but retaining a small one on the inner breakwater, adding as a supplementary estimate, an extension of the former, to obviate the necessity of ever having occasion to build the outer breakwater.

Respectfully submitted.

GEO. R. BALDWIN.

CHARLESTOWN, March 25th, 1862.

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*ESTIMATE of the Cost of Opening a Ship Canal across Cape Cod, from Buzzard's Bay to Barnstable Bay, for Vessels and Steamers, not exceeding* 350 *feet long,* 90 *feet wide, above water line, and* 18 *feet draft of water, embracing the cost of the locks, sluices, basins, harbors, breakwaters and dredging, from termini of Canal, to deep water in the Bays, according to the details shown on the accompanying map of Surveys, made by Mr. J. G. Chase.*

| ITEMS OF WORK DONE. | Quantities. | Price in Cents. | Short Amounts. | Total Amounts. |
|---|---|---|---|---|
| Dredging a channel 600 feet wide, for vessels drawing 18 feet, from Wenaumet Neck to Back River Harbor, | 35,011,835 c. ft. | ½ | – – | $175,059 17 |
| Dredging out Back River Harbor, and for the sea walls on its sides, | 7,335,120 c. ft. | ½ | – – | 36,675 60 |
| Dry rubble wall of large dimensions, stones for the harbor walls, laid by diving bell, from lock to Stony Point, | 504,339 c. ft. | 25 | – – | 126,084 75 |
| Do. for walls on the south and north-east side of harbor, | 285,485 c. ft. | 25 | – – | 71,371 25 |
| Excavation for lock pit, part to be dredged, | 6,564,533 c. ft. | ½ | $32,822 66 | |
| Driving 800 round timber piles for enclosing the space for concrete foundation, except on the harbor side, | 800 piles. | 260 | 2,080 00 | |
| Lumber for ribbon, and sheathing for same, | 84,400 sq. ft. | 1½ | 1,266 00 | |
| Iron bolts for ribbons, &c., | 7,168 lbs. | 8 | 573 44 | |
| Driving piles for bridges and stagings outside enclosure, | 108 piles. | 225 | 243 00 | |
| | 42 piles. | 200 | 84 00 | |
| Lumber for same, Caps and stringers, | 90,066 sq. ft. | 1½ | 1,350 99 | |
| Lumber for same, Plank for floors, | 67,328 sq. ft. | 2 | 1,346 56 | |
| Iron work and nails, | . . . | . . | 250 00 | |
| Labor for making bridges and stagings, | . . . | . . | 1,000 00 | |
| Mortar mills for making concrete, float stages, and other tools, for immersing the concrete, | . . . | . . | 2,000 00 | |
| Running concrete for foundation side walls, and coffer dams of lock, labor and materials, | 1,578,378 c. ft. | 12 | 189,405 36 | |
| Excavating concrete for gate recess, &c., | 60,303 c. ft. | 4 | 2,412 12 | |

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| | | | | |
|---|---|---|---|---|
| Quarrying concrete coffer dams at head and foot of lock, | 62,160 c. ft. | 6 | $3,729 60 | |
| Lumber for staging inside enclosure required before running the side walls of the lock and two coffer dams, consisting of posts, caps, girders, braces, &c., | 271,996 c. ft. | 1½ | 4,079 94 | |
| Plank for staging, | 98,176 c. ft. | 2 | 1,963 52 | |
| Iron work and nails, | . . . | . . | 500 00 | |
| Labor for framing and setting up staging, | . . . | . . | 2,000 00 | |
| Rubble stone work laid in hydraulic mortar, required inside the concrete walls before laying cut stone masonry, | 192,130 c. ft. | 20 | 38,426 00 | |
| Cut-stone masonry laid in hydraulic mortar, for invert, recesses and sides of lock, | 458,590 c. ft. | 60 | 275,154 00 | |
| Pump, well, engine-house and culvert, as follows— | | | | |
| Tunnelling through concrete, | 910 c. ft. | 5 | 45 50 | |
| Brick tunnels, | 620 c. ft. | 35 | 217 00 | |
| Stone work for bottom of well, | 716 c. ft. | 60 | 429 60 | |
| Stone work for five rings in side of well, | 1,303 c. ft. | 50 | 651 50 | |
| Brick work laid in hydraulic mortar for well, | 2,332 c. ft. | 35 | 956 20 | |
| Cast-iron paddle-gate, with brass facings and screw, for closing tunnel, | . . . | . . | 230 00 | |
| Foundation based on concrete for engine-house, | 3,900 c. ft. | 20 | 780 00 | |
| Underpinning for same, | 624 c. ft. | 35 | 218 40 | |
| Brick walls of engine-house 52x36 feet square, including slated roof, three floors, doors, windows and chimney, | . . . | . . | 3,420 94 | |
| Back-filling sides of lock with compacted earth brought up level with coping, | 4,316,878 c. ft. | ½ | 21,584 39 | |
| Cutting rabbets in cut-stone masonry for gate cushions, | 1,544 sq. ft. | 100 | 1,544 00 | |
| Three wrought-iron lock-gates or caissons furnished with kentlage chamber, air-chamber, puddle-gates and other apparatus for working the gates, | . . . | . . | 150,000 00 | |
| One 40-horse power steam-engine, with pumps for draining the lock and for working gates, | . . . | . . | 20,000 00 | |
| Expense of draining the work while finishing the interior of the lock, | . . . | . . | 2,000 00 | |
| Total cost of Back River Lock, | . . . | . . | | $762,764 72 |
| *Amount carried forward,* | . . . | . . | . . | $1,171,955 49 |

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*Estimate of the Cost of Opening a Ship Canal across Cape Cod*—Continued.

| ITEMS OF WORK DONE. | Quantities. | Price in Cents. | Short Amounts. | Total Amounts. |
|---|---|---|---|---|
| *Amount brought forward*, | | | | $1,171,955 49 |
| Revetment wall 26 feet high along west side of canal basin, at Back River lock, for a distance of 1,500 feet, including the wing walls at head of lock, | 314,582 c. ft. | 20 | – – | 62,916 40 |
| Cost of changing the line of the Cape Cod Railroad, from a point near the east end of the railroad bridge, across outlet of Buttermilk Bay, to a point about 3,000 feet east from Monumet depot, exclusive of the cost of draw-bridge over canal—length of new location 2¼ miles, at $12,000 per mile, | | | $27,000 00 | |
| New rail required for extra length of railroad line, | 1,700 feet. | 120 | 2,040 00 | |
| Draw-bridge abutment and recess walls, | 124,826 c. ft. | 20 | 24,965 20 | |
| Excavation for abutment and recess walls, | 116,200 c. ft. | ½ | 581 00 | |
| Back-filling abutment and recess walls, and for raising embankments to proper height, | 169,185 c. ft. | ¾ | 1,268 88 | |
| Lumber required for covering recess and for supporting railroad track, | 121,536 sq. ft. | 1½ | 1,823 04 | |
| Plank for floor over recess, | 17,100 sq. ft. | 2 | 342 00 | |
| Wrought-iron draw-bridge or caisson, with geering, | | | 44,400 00 | |
| | | | $102,420 12 | |
| Altering railroad at North Sandwich, | 6,500 feet. | 150 | 9,750 00 | |
| Moving depot building from old to new location, $500 00 | | | | |
| Deduct value of 400 feet railroad iron, 480 00 | | | | |
| | | | 20 00 | |
| Total cost for changing railroad at Monumet and North Sandwich, | | | | 112,190 12 |
| Sluice-way for admitting Herring Brook into the Canal at North Sandwich, viz.: | | | | |
| Brick water-stop laid in hydraulic mortar, | 379 c. ft. | 30 | $113 70 | |
| Hydraulic stone masonry for sides and bottom of sluice, | 21,496 c. ft. | 20 | 4,299 20 | |
| Lumber for sheet-piling at canal end of sluice, | 1,752 sq. ft. | 2 | 35 04 | |

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|---|---|---|---|---|
| Paving canal slopes and bottom around sluice, | 1,800 c. ft. | 3 | $54 00 | |
| Paving head of sluice, | 375 c. ft. | 2 | 7 50 | |
| Making draw-bridge and other labor, | . . . | . . | 230 00 | |
| Total cost of sluice-way and ferry landing, | . . . | . . | | $4,739 44 |
| Excavation for Scusset lock and sluice, at termination of the Deep-Cut or Scusset line at seashore, | 8,128,842 c. ft. | ½ | $40,644 21 | |
| Driving 1,050 round timber piles for enclosing the space for concrete foundations, except side next to sea, | 1,050 piles. | 260 | 2,730 00 | |
| Lumber for ribbons and sheathing, | 120,283 sq. ft. | 1½ | 1,804 25 | |
| Iron bolts for securing ribbons to piles, | 9,408 lbs. | 8 | 752 64 | |
| Driving piles for bridges and stagings outside lock, | . . . | . . | 327 00 | |
| Lumber for bridges and stagings inside and outside lock, | . . . | . . | 8,741 01 | |
| Iron work and nails for same, | . . . | . . | 750 00 | |
| Labor on bridges and staging for lock, | . . . | . . | 3,000 00 | |
| Lumber for staging inside and outside enclosure for sluice, except plank, | 136,796 sq. ft. | 1½ | 2,051 94 | |
| Plank for stagings, | 45,000 sq. ft. | 2 | 902 00 | |
| Driving piles outside enclosure of sluice, | 50 piles. | 260 | 130 00 | |
| Iron for sluice stagings, | . . . | . . | 300 00 | |
| Labor on stagings for sluice, | . . . | . . | 1,500 00 | |
| Mortar mills and other tools for running concrete for lock and sluice, | . . . | . . | 3,300 00 | |
| Concrete run for foundations, side walls, and coffer dams for lock and sluice, and adjoining wing and revetment walls, | 2,389,998 c. ft. | 12 | 286,799 76 | |
| Excavating concrete for gate recesses and lock sides and sides of sluice, | 106,081 c. ft. | 4 | 4,243 24 | |
| Quarrying concrete coffer dams at ends of lock and sluice, | 156,768 c. ft. | 6 | 9,406 08 | |
| Rubble wall laid in hydraulic mortar for interior of lock and sluice, | 299,549 c. ft. | 20 | 59,909 80 | |
| Cut-stone hydraulic masonry for lock and sluice, | 616,615 c. ft. | 60 | 369,969 00 | |
| Engine-house, pump, well, and one tunnel same as Back River lock, | $6,949 14 | | | |
| Extra brick work in side wall of well, | 54 60 | | | |
| *Amounts carried forward*, | $7,003 74 | . . . | . . | $798,260 93 | $1,351,801 45 |

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*Estimate of the Cost of Opening a Ship Canal across Cape Cod*—Continued.

| ITEMS OF WORK DONE. | Quantities. | Price in Cents. | Short Amounts. | Total Amounts. |
|---|---|---|---|---|
| *Amounts brought forward,* . . . . . $7,003 74 | | . . | $798,260 93 | $1,351,801 45 |
| Add brick work in tunnel to sluice, . . . . . 217 00 | | | | |
| Add stop-gate for tunnel to sluice, . . . . . 230 00 | | | | |
| . . . | . . | | 7,450 74 | |
| Back-filling sides of lock and sluice level with coping, . . . . . | 1,992,109 c. ft. | ½ | 9,960 55 | |
| Cutting rabbets for gate cushions for lock and sluice, . . . . . | 2,135 sq. ft. | 100 | 3,135 00 | |
| Three wrought-iron lock-gates or caissons, with geering complete, . . . | . . . | . . | 150,000 00 | |
| One wrought-iron bulkhead for sluice, provided with 24 paddle gates for feeding canal, . . . . . | . . . | . . | 60,000 00 | |
| One 40-horse power engine with pumps, &c., . . . . . | . . . | . . | 20,000 00 | |
| Draining enclosures of lock and sluice, while executing the masonry inside, . | . . . | . . | 3,000 00 | |
| Revetment walls connecting lock with sluice, . . . . . | 162,525 c. ft. | 20 | 32,505 00 | |
| Revetment walls for wings to west side of sluice-way, . . . . . | 74,503 c. ft. | 20 | 14,900 60 | |
| Total cost of Scusset Lock and Sluice, . . . . . | . . . | . . | | 1,094,912 82 |
| Revetment wall along west side canal basin, extending from wing wall of sluice, a distance of 1,045 feet, . . . . . | 376,200 c. ft. | 20 | – – | 75,240 00 |
| Pier wharf in canal basin, projecting from head of lock, 40 feet wide and 200 feet long, with piles of oak, . . . . . | 200 feet. | 22.77 | $4,554 00 | |
| Pier wharf projecting from sea end of lock, 40 feet wide and 200 feet long, . | 200 feet. | 25.00 | 5,000 00 | |
| | | | | 9,554 00 |
| Pier wharf extending from the east wing wall of Scusset lock, along the westerly side of the Inner Breakwater, a distance of 1,630 feet, . . . | 1,630 feet. | 25.00 | $40,750 00 | |
| Inner Breakwater (Scusset line), built of rubble stone, and surmounted by a hydraulic mortar wall, following the easterly side of the last mentioned pier wharf—rubble stone work, . . . . . | 211,245 c. ft. | 7 | 341,015 15 | |

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| Parapet wall laid in hydraulic mortar, | 301,574 c. ft. | 30 | $90,472 20 | |
| Paving berme on east or outer side, in hydraulic mortar, | 16,137 c. ft. | 15 | 2,420 55 | |
| Cut-stone conical beacon at head of breakwater, | | | 500 00 | |
| | | | | $475,157 90 |
| Excavation for canal across the Cape, from head of Back River lock to head of Scusset lock, via Deep-Cut or Scusset line, including the basins at the locks, | 8,969,026 c. yds. | 15 | – – | 1,345,353 90 |
| Dredging channel from Scusset lock and sluice, to deep water in Barnstable Bay, along the west side of the Inner Breakwater and Pier, | 3,555,150 c. ft. | ½ | – – | 17,775 75 |
| Land required for the canal, | 760 acres. | 50.00 | $38,000 00 | |
| Houses and out-buildings standing on the above-mentioned land, | | | 20,000 00 | |
| Mill on the Monumet River at North Sandwich, | | | 2,000 00 | |
| | | | | 60,000 00 |
| Western Breakwater—Rubble stone work, | 18,702,468 c. ft. | 7 | $1,309,172 76 | |
| Cut-stone wall laid in hydraulic mortar, with hearting of concrete, | 1,170,453 c. ft. | 30 | 508,215 90 | |
| Concrete for inside of wall, | 537,737 c. ft. | 14 | 75,283 18 | |
| Stone beacon for head of breakwater, | | | 500 00 | |
| Total cost of Western Breakwater, | | | | 1,893,171 84 |
| Outer Breakwater—Rubble stone work, | 29,401,187 c. ft. | 7 | $2,058,083 09 | |
| Cut-stone wall laid in hydraulic mortar, exclusive of concrete hearting, | 1,714,446 c. ft. | 30 | 514,333 80 | |
| Concrete for inside of wall, | 695,794 c. ft. | 14 | 97,411 16 | |
| Beacon for south head of breakwater, | | | 500 00 | |
| Light-house on western head of breakwater, | | | 20,000 00 | |
| Total cost of Outer Breakwater, | | | | 2,690,328 05 |
| | | | | $9,013,294 71 |
| Superintendence and contingencies, 10 per cent., | | | | 901,329 47 |
| Total cost of Canal, Locks and Breakwater, &c., for Scusset line, | | | | $9,914,624 18 |



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